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A WINDOW OPEN ON THE WORLD

The UNESCO Courier

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68 pages

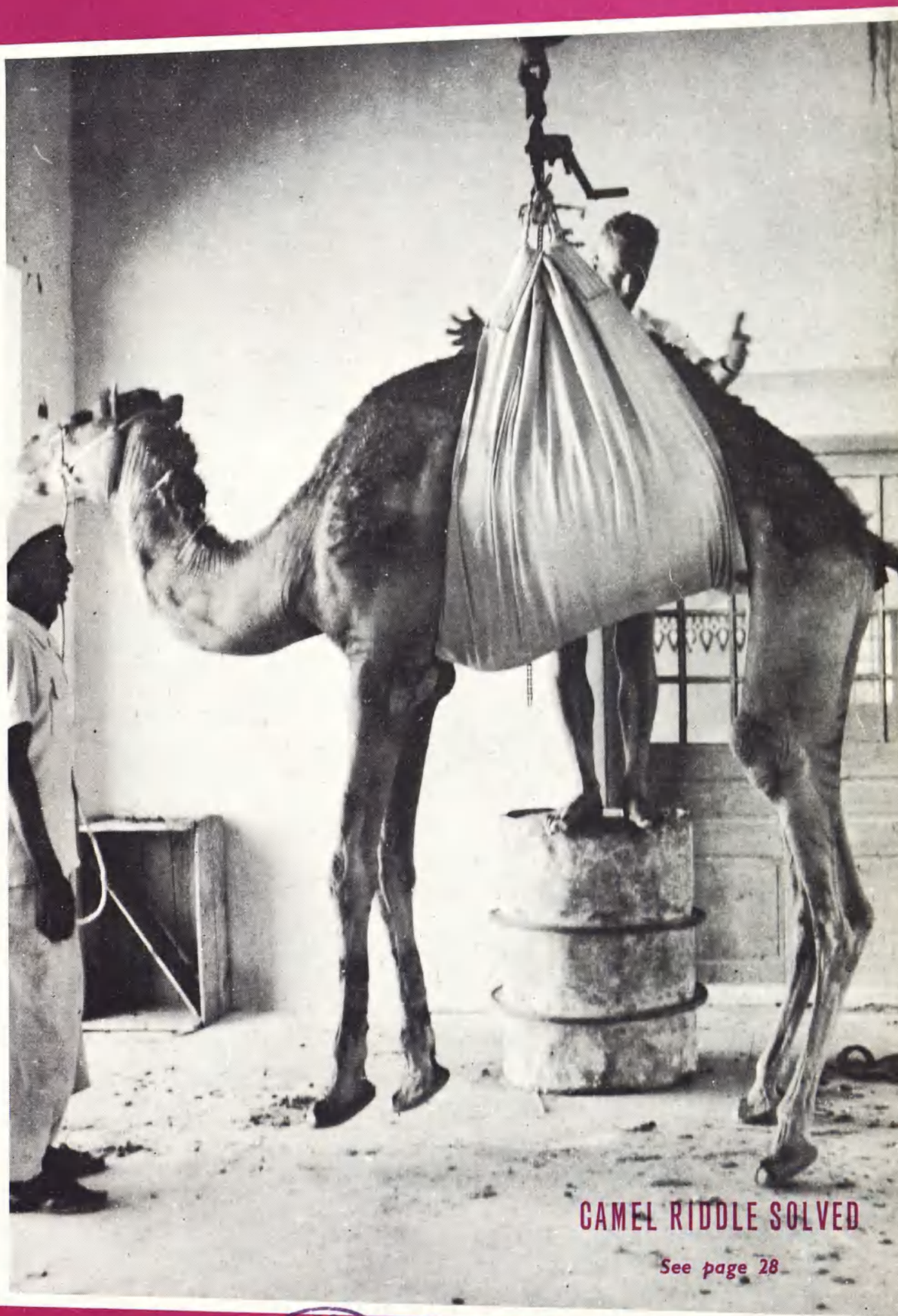
CONQUEST OF THE DESERT

Harnessing power from sun & wind

Pros and cons of artificial rain

Growing food without soil

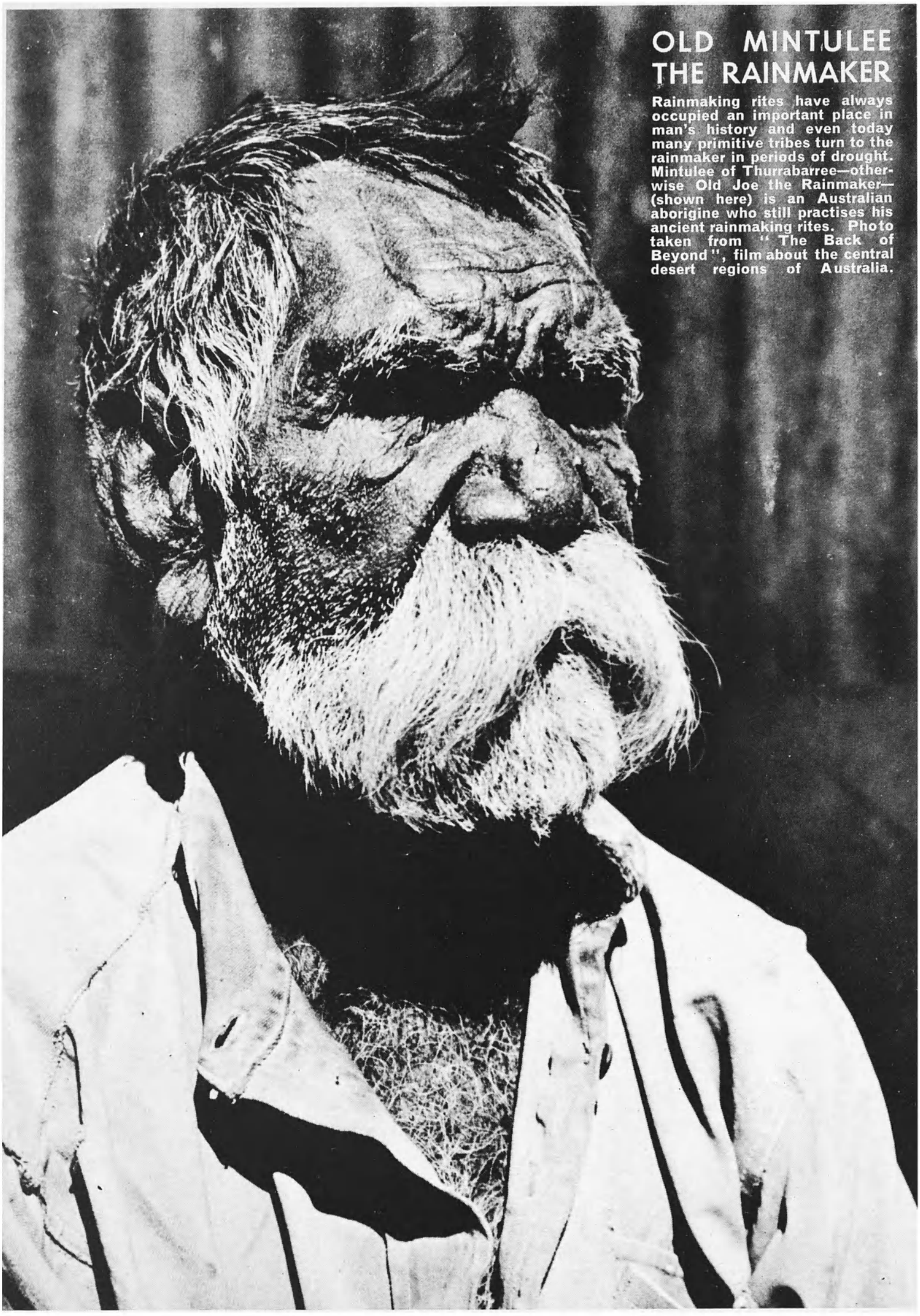
Strange, rich art deep in the Sahara



CAMEL RIDDLE SOLVED

See page 28

UNESCO ARCHIVES



OLD MINTULEE THE RAINMAKER

Rainmaking rites have always occupied an important place in man's history and even today many primitive tribes turn to the rainmaker in periods of drought. Mintulee of Thurrabarree—otherwise Old Joe the Rainmaker—(shown here) is an Australian aborigine who still practises his ancient rainmaking rites. Photo taken from "The Back of Beyond", film about the central desert regions of Australia.

The UNESCO Courier
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UNESCO stands for United Nations Educational, Scientific and Cultural Organization. It is one of the Specialized Agencies of UN, the United Nations. "The purpose of the Organization is to contribute to peace and security by promoting collaboration among the nations through education, science and culture... To realize this purpose the Organization will collaborate in the work of advancing the mutual knowledge and understanding of peoples, through all means of mass communication... maintain, increase and diffuse knowledge... by initiating methods of international co-operation calculated to give the people of all countries access to the printed and published materials produced by any of them." (From the Constitution of UNESCO.)

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COVER PHOTO

The mystery of how the camel can go for so long without water has now been solved by a Unesco-sponsored research team in the Sahara Desert. Camel's weight is checked here after beast was deprived of water for eight days. For some startling findings on the camel see page 28 (Photo copyright Schmidt-Nielsen)

THE infinite variety of life is one of the most intriguing topics for nature-lovers and for scientists whose lives are devoted to understanding the world. Part of its fascination is the amazing adjustment of plants and animals to the various conditions of living. Through countless generations of the slow process of mutation they have gradually altered not only their habits but their anatomy and physiology to fit them for life in the depths of the sea, the jungle tree tops or even beneath the soil. Each species is marvellously fitted to a specific type of environment, but each is also unfitted for life in a different one.

There is only one species of animal that has the ability to live anywhere on earth except under water: man. He has adapted not so much by changing his nature in the course of generations as merely by adapting the environment to himself by inventing clothes for cold weather, shelter against the storms, fire for making hard foods edible, and tools to master the soil. Man has made almost every patch of the earth somehow habitable.

Yet there are large areas that are almost deserted by man and where only those men live whose wants are meagre and who thrive on solitude. "Terra deserta", the Romans called these deserted areas—whence the modern word "desert". They need not be hot, for there are deserts in the Arctic and on cold high plateaus. But a desert is always dry, its vegetation is sparse, animals rare and men poor. In the deserts, neither ancient nor modern science has accomplished much improvement.

One practical definition of science is that it is the best use of the human intelligence to improve the conditions under which we live. Thus, the desert still is one of the greatest challenges to mankind and to science. More than one-fourth of the entire land area of the earth is almost useless because it has too much sun, not enough rain. To improve living conditions in the desert may require improving the climate or at least the weather, and both of these have everywhere been beyond man's control.

Before science can act it must understand. It needs to know the cause of dryness and the reasons for lack of rain; it must understand the geological structure of rocks and the types of soil and of sand in order to find underground water. It must understand what means are used by desert plants and animals to thrive and live so happily in austerity; it must know the wind and the sun and know how to harness them and use their energy to improve living conditions. Furthermore, the problem is so vast that it involves the lives of people of at least 37 nations. No single nation can accomplish much but what one does can benefit all. The problem of the arid lands is therefore an international one, to be solved by the best use of the human intelligence on a world scale. It has for this reason demanded the attention of the United Nations Educational, Scientific and Cultural Organization since it was first organized.

Practical progress has been slow, but the growth of understanding has not. Small successes in adjustment have appeared, such as the use of dew for plant growth; applying the lessons that the camel can teach; the prevention of the spread of the desert through misuse of the marginal areas. Further successes seem imminent such as the location of underground water, the use of the wind for operating local wells, the use of sunshine for cooking, and perhaps even the production of fresh water from the sea for use in irrigation. This is one of the liveliest of the scenes where science is now at work.

Because so much of UNESCO's efforts has gone into this many-sided problem this issue of the UNESCO COURIER is a review of the present status of the great campaign to make the deserts habitable and to extend man's realm to the farthest, driest and in many ways pleasantest regions of this planet.

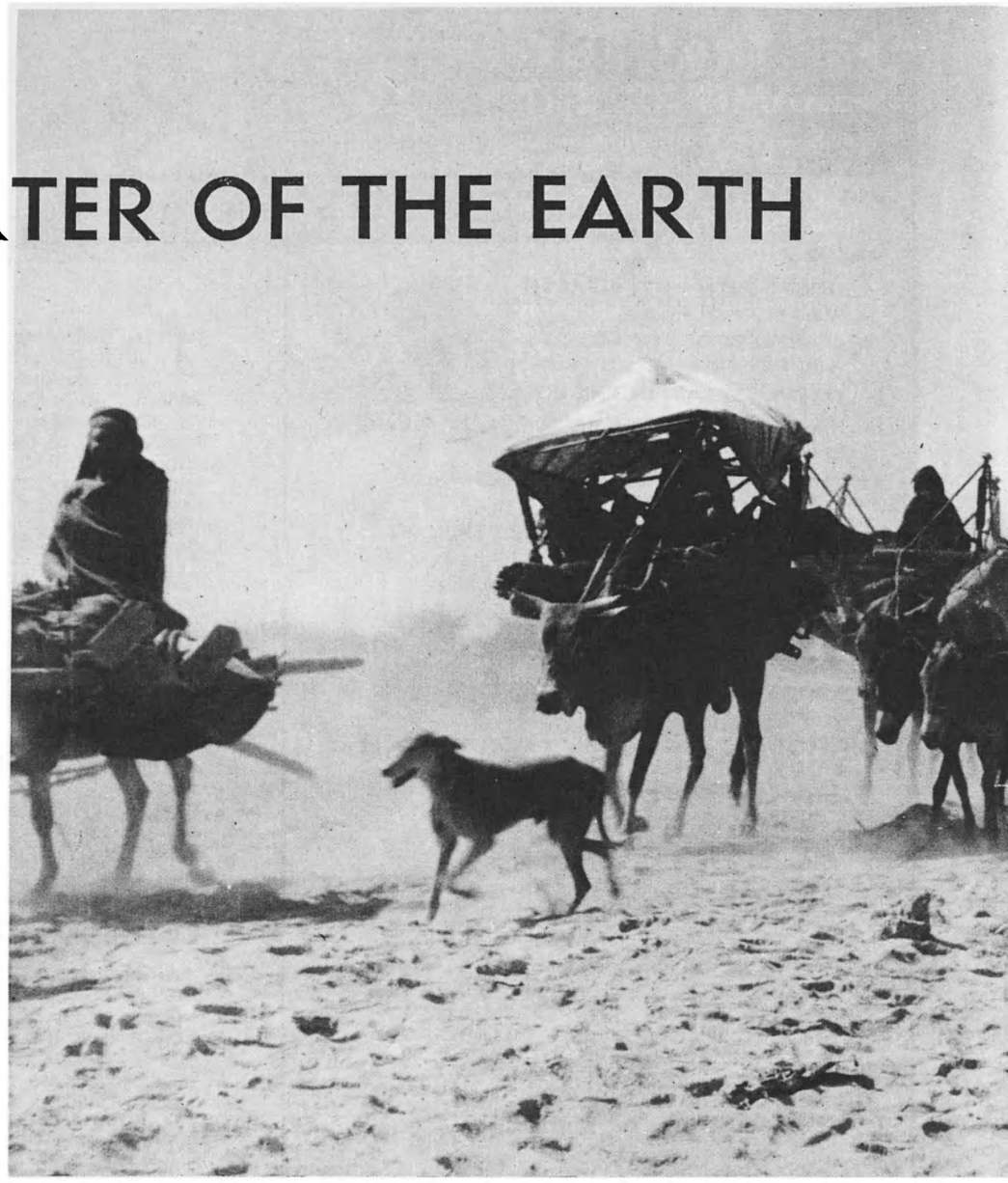
Gerald WENDT.

UNESCO ARCHIVES

A major Unesco problem

ONE QUARTER OF THE EARTH IS ARID

by James Swarbrick



ONE of the purposes of the United Nations Educational, Scientific and Cultural Organization is to improve the living conditions of mankind through scientific research. Very soon after Unesco was organized this high purpose came down to earth as the fact was faced that more than one quarter of the land area of the earth is able to support but a thin population at a very low standard of living because it lacks sufficient water.

The arid zone sweeps across the map from the Atlantic across the Sahara in North Africa into Arabia, Pakistan and on across the great Gobi in China. Another band runs north and south close to the Pacific Coast almost from Alaska to the tip of South America, with only a wet gap in Central America. A large part of South Africa is arid, as is all but the eastern rim of Australia. In all of them the problems are similar if not the same.

They were, in fact, under attack in many lands, but independently and separately. Unesco's first action was a survey of research already in progress which resulted in a directory of almost 100 research institutions, devoted at least partly to aridity, in 23 countries—and this did not include the Soviet nations which were not then members of Unesco. The survey also showed that most of the research was concentrated in those countries that were arid only in part, like the United States, and thus had enough wealth from their rich areas to support research. The wholly arid countries, which needed it most, could not afford it. Clearly joint international action, which would focus many special sciences on the problem, offered the only solution and, if successful, would benefit the arid lands everywhere.

Hidden waters

WHAT Unesco attempts to achieve through its arid zone programme is to stimulate an awareness in all countries of the aridity problem, to foster research directed towards its solution, and to spread the knowledge needed to apply the results of research to common use. The work is conducted under the guidance of an "Advisory Committee on Arid Zone Research", with nine members who come from different countries and who are experts in the different sciences involved. The Committee sessions are attended by representatives of the United Nations, of the Specialized Agencies that have arid zone interests, (such as the Food and Agriculture Organization, the World Health Organization and the World Meteorological Organization) and of some international organizations of scientists and engineers, such as the International Union of Geography and the World Power Conference.

One great problem common to all arid areas is the lack of water. This may be absolute, because no rain or very little rain falls, or it may be relative, because what rain does fall is not available to support a utilizable vegetation. So in some arid areas the problem is to find water supplies, and in others the population must be protected against drought, and planned use made of what water there is.

When rain falls on the ground, some of it remains in the upper levels of the soil and either is used by plants or is evaporated. Some of the rain, however, sinks into the earth, where it may be drained away by streams and rivers, or it may remain underground, travelling very slowly through permeable rocks. If these rocks can be reached from the surface by boring, then the water can be lifted by pumps and used for drinking purposes and for irrigating the soil; or, if the water-bearing rock is between two impermeable strata, the water will gush out as an artesian well.

Rainfall in arid areas, though deficient, often results in floods which cause erosion, since the water loosens and carries away with it the upper soil later. Thus not only is the water wasted but the land is impoverished. The damming of rivers and the building of reservoirs to impound flood water are thus imperative. At the present time India leads the world in irrigation from rivers, but the planned development of river resources advances wherever rivers flow through arid areas.

Evaporation from the surface of impounded water can represent a serious loss in arid areas. The construction of deeper reservoirs with less surface is one way of reducing the loss. A more radical solution is to allow the water to seep underground through specially prepared percolation beds and store it there to be pumped up as required.

If an economic method could be devised whereby the salts could be removed from sea-water and from salty underground water which is all too frequently found, perhaps the greatest

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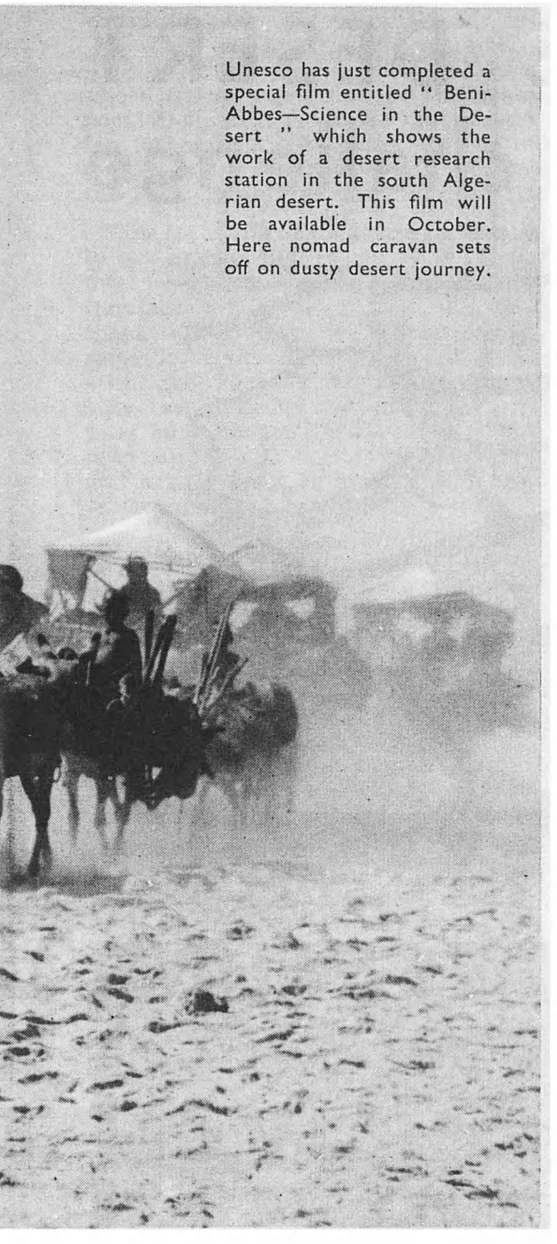
James SWARBRICK is in charge of Unesco's Arid Lands Programme and is secretary of the Unesco Advisory Committee on Arid Zone Research. A specialist in chemistry, he was formerly a science officer with the British Council.



Unesco has just completed a special film entitled " Beni-Abbes—Science in the Desert " which shows the work of a desert research station in the south Algerian desert. This film will be available in October. Here nomad caravan sets off on dusty desert journey.

single step would have been taken towards desert reclamation. Unesco is now giving this problem special attention. The map of the world's deserts (*page* 8) shows that many of them lie along the coasts, especially the western coasts of the continental land masses. The coastal deserts of Chile and Peru are extreme examples. With the sea in sight, water has to be brought by pipe line or even by railway tank cars from the other side of the Andes. But so far no process has been discovered to remove that salt from sea water at a cost that permits the large-scale utilization of fresh water. Another possibility of increasing water supply is to provoke rainfall artificially. In recent years much research has been devoted to it, with considerable success but with no certain method yet established. (*See page* 51.)

A problem secondary only to that of water supplies in arid areas is the provision of energy. It is needed for pumping water, for domestic and farm use, for industry, for the exploitation of mineral wealth. It is needed above all to remove the pressure that exists in all arid areas to cut down trees and shrubs for fuel. People whose immediate need is firewood do not take willingly to conservation.

The prevention of the spread of deserts is at least as important as the reclamation of areas which have been deserts for thousands of years. Land on the fringes of deserts is in a very delicate equilibrium, and unless great care is exercised in using it, and especially in cultivating it, this equilibrium will be upset and the desert will inexorably march on.

Dew-fed plants

THE methods of preventing erosion are now well known. They include contour ploughing, the setting up of wind breaks, the prevention of floods, and above all scientific knowledge of what a given area can and cannot produce. Unfortunately these methods are not always applied.

It is Unesco's purpose to guide and correlate the many researches in all these fields that are under way in a score of countries and to make sure that advances in knowledge in any field and in any country are shared by other research men throughout the world. The Advisory Committee on Arid Zones Research meets twice a year for a detailed discussion of research progress. Once a year one of the topics is stressed as a subject of a general symposium to which scientists of the world are invited. The next symposium will be held in Australia in October 1955 and will be devoted to the study of climate. In previous years the meetings have been devoted to hydrology (the study of water supply) at Ankara in Turkey in 1952, on plant ecology at Montpellier in France in 1953 and on wind and solar energy at New Delhi, India in 1954.

The Committee also authorizes a number of general projects such as the drawing of accurate maps of conditions in arid lands. Funds are also allocated for special research projects such as the one on the physiology of the camel (*reported on page* 28) and the study of the role of dew in providing moisture for plant growth, made by Prof. S. Duvdevani of the Hebrew University in Jerusalem. Prof. Duvdevani found that certain plants can draw water from dew through their leaves into the roots and even into the soil for storage.

The Unesco Arid Zone Committee also supports international meetings that are sponsored locally. For instance, in the spring of 1955 the Committee met with and assisted the American Association for the Advancement of Science in the programme of its International Arid Lands Meetings at Albuquerque and Socorro, New Mexico. This series of meetings was attended by nearly 500 scientists from 28 countries and by a large number of farmers and business men from the arid area of the southwestern United States. In November of 1955 Unesco will collaborate in a world meeting on Applied Solar Energy at Phoenix, Arizona, USA.

In addition, other departments of Unesco are active in promoting the interests of arid lands. The Exchange of Persons Service annually awards a number of fellowships to enable persons from the arid lands to travel abroad for training in new techniques and for an exchange of information and experience. So also the Technical Assistance Department of Unesco is able to respond to requests from its member states for assistance in projects of arid zone development.

Thus a geophysical institute has been established in Pakistan and a hydrogeological institute in Turkey. A Unesco mission is working in Mexico to establish a research institute on atmospheric physics and hydrology—with a view to increasing the rainfall and better control of the waters that fall. Peru has asked for assistance in establishing an institute for research in Peruvian desert conditions. Other experts have been sent to the Desert Research Institute at Heliopolis in Egypt to assist in extending its work, and a survey of wind energy has been carried out in Israel.

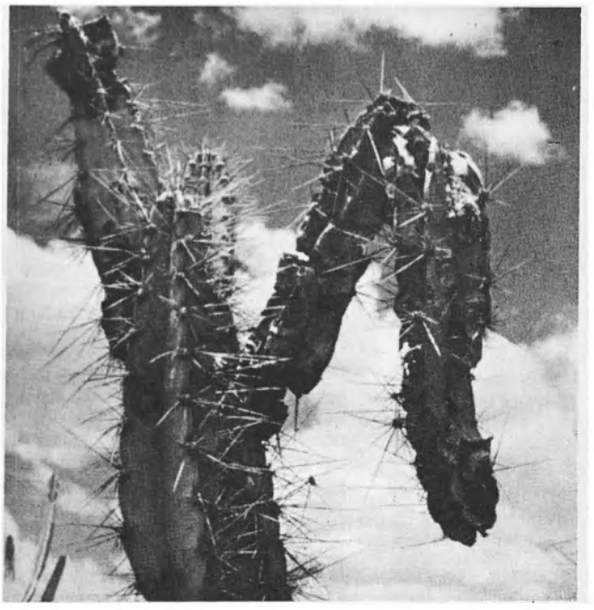
Deserts of stone

THE residents of large cities are often unconcerned about the desert and do not realize that the cities are themselves deserts of stone where no food is given and water is spent largely in sanitation. But to the people of one fourth of the earth the lack of water and the many related topics that have been mentioned are basic to life itself.

While active research is in progress much could be done if the media of public education and information were used to encourage the residents of dry lands to apply the best of present knowledge to their own farms and communities and thus to advance the conquest of the desert.

Unesco's "General Staff" in the battle against the desert—the nine-man Unesco Advisory Committee on Arid Zone Research. Front row (L to R) Dr. Georges Aubert, soil scientist, France; Dr. B.T. Dickson, plant pathology and plant introductions, Australia; Mr. J. Swarbrick, Unesco; Back row (L to R); Dr. Gilbert F. White, geographer, U. S. A.; Prof. H. O'R. Sternberg, geographer, Brazil; Prof. R. E. G. Pichi-Sermolli, botanist and plant ecologist, Italy; Dr. Soubbi Mazloum, hydrologist, Syria; Dr. Herbert Greene, soil scientist, United Kingdom; Mr. S.N. Naqvi, meteorologist, Pakistan. (Unesco photo.)

CONQUEST OF THE DESERT
Science accepts the challenge



Unicef Photo.

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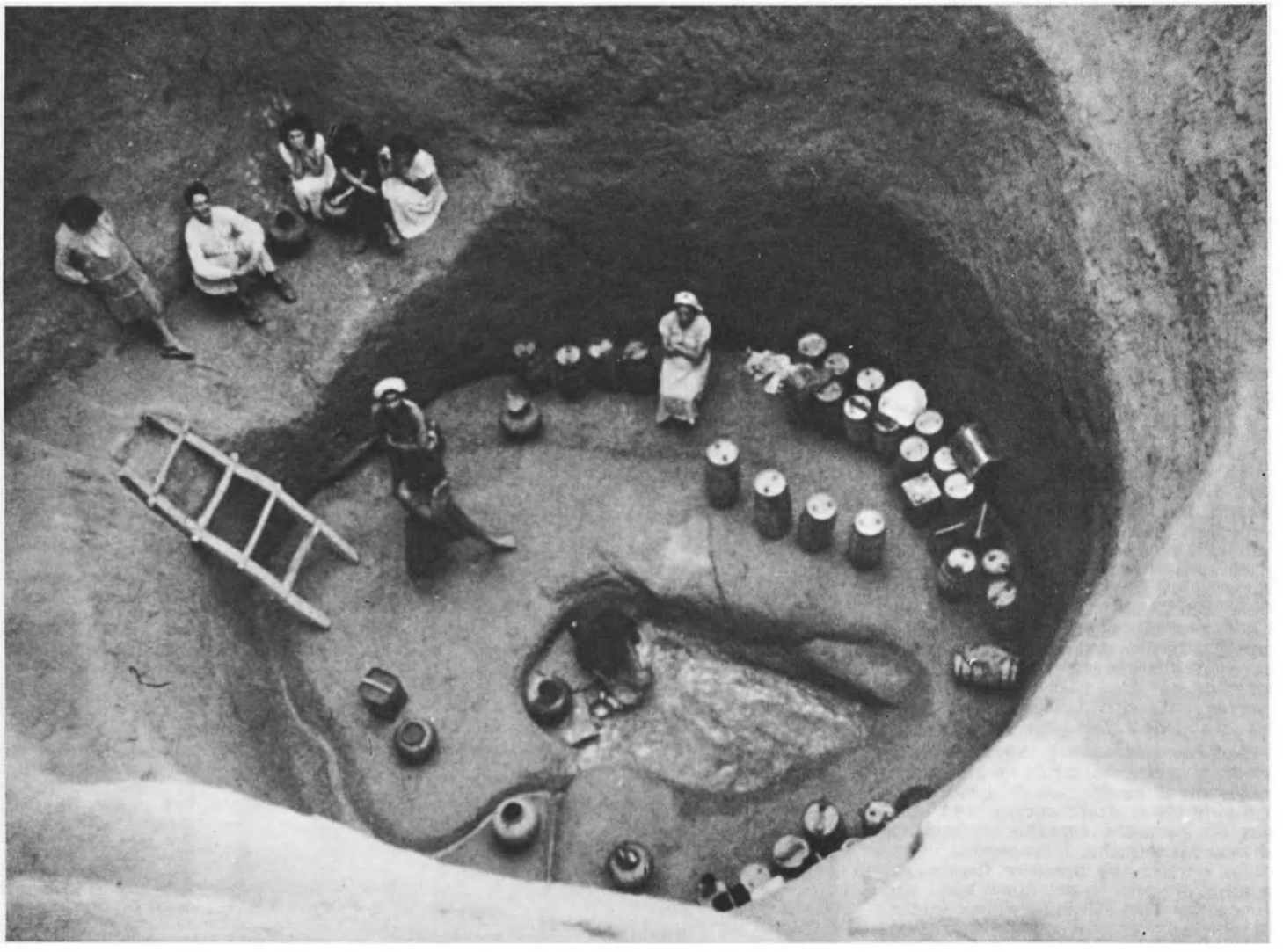


OLD WATERHOLES, dug deeper by each generation, form oases in the drought-stricken north eastern hump of Brazil. Here, at Campina Grande, men and women wait for water in the coolness of the earth. (For an article on Brazil's " Polygon of Drought ", see Unesco Courier N° 2, 1955). (Unicef Photo)

ARID lands, wherever they may be located, especially if they are hot, are characterized by intense blue skies by day, immense distances in a shimmering atmosphere, sparse vegetation and still sparser animal and human population, with a limited and erratic rainfall of less than ten inches in a good year. Yet we recall that great civilizations were developed in arid areas crossed by great rivers, the Tigris-Euphrates, the Indus and the Nile.

How big is the challenge so far as area goes? It is difficult to get precise figures but it is generally believed that the total land surface of the earth is of the order of twenty-five thousand million acres and of this at present about two thousand five hundred million, or ten percent, are under some form of cultivation. But it is also estimated that about six thousand four hundred million acres are arid, in other words about one quarter of the total land surface of the earth. That is to say the arid area is just over two and a half times as large as the presently cultivated area.

The end of the First World War saw the end of large scale settlement in, and development of, new lands by pioneering individuals in whom the spirit of adventure or the desire for a freer life was strong. Came the Second World War with a startling realization of the precarious way in which most nations lived, a way fraught with all the explosive possibilities of further bitter struggles between peoples.

Today we know that Malthus was just ahead of his time and we have to ask ourselves whether adequate food requirements of the people can be provided from present sources with

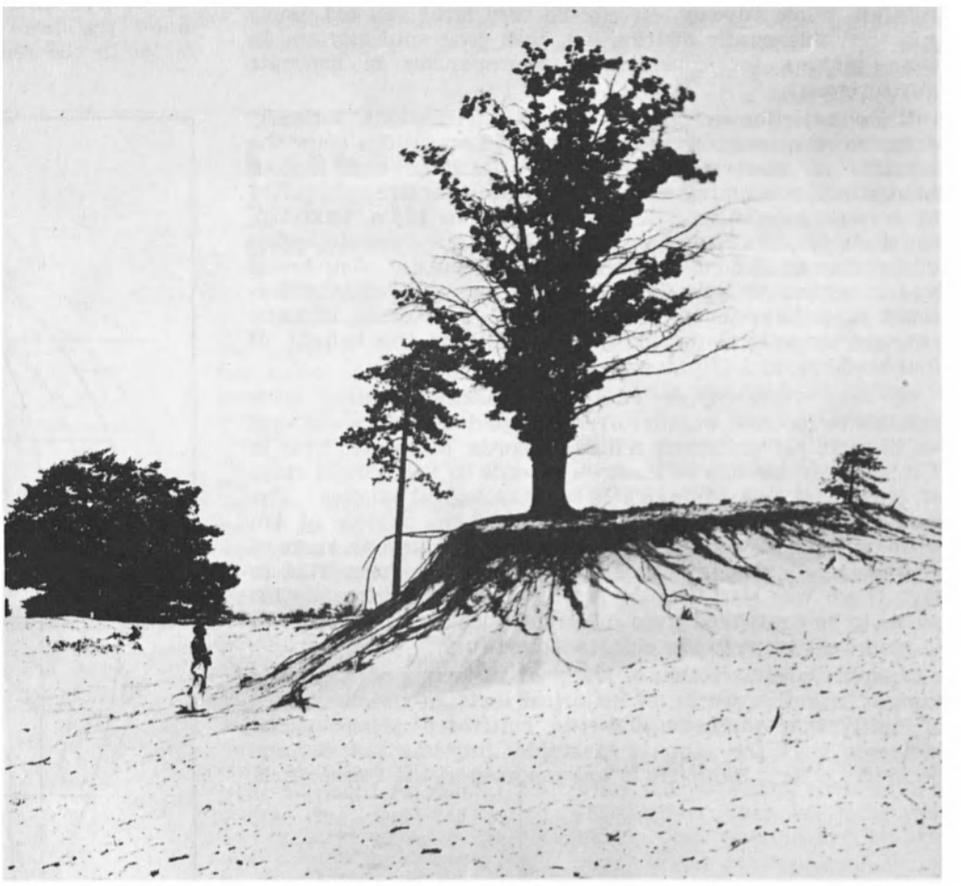
by B. T. Dickson

all the technological experience available to us. We suggest that two possibilities arise, one a reduction in the rate of growth of the population of the world and the other an increase in production of foodstuffs not only just to feed people on a minimal diet but on a diet nearer to the optimal. With the control of the rate of population growth we arid zone people have little or nothing to do. We do say, however with regard to the second, that it is possible to increase world food supplies by increasing production from present areas and by bringing into production more land at present uneconomically used.

By applying technological knowledge to the fullest extent in what are at present underproducing areas a great increase in food production by individual growers is possible. India, for example, possesses irrigation works on a great scale and nowhere else in the world is so large a population dependent on irrigation for food supplies and yet it is estimated that less than ten per cent of the run-off of her rivers is utilized.

When we come to consider the possibilities in arid lands it is recognized that the efforts of individual growers can play but a small part in the development of new areas of production or the re-establishment of production in great areas which used to be fertile in ancient times, and are now out of use. I refer to the millions of acres in the valleys of the Tigris-Euphrates, the Indus-Chenab and the Nile, in the dry north of Ceylon where still are to be seen the remains of ancient irrigation channels and reservoirs.

It is estimated that in Latin America over twelve million acres are susceptible of development, and an area bigger than Egypt's productive land is said to be available in the middle Niger. The re-establishment of these ancient areas and the development of new areas require the joint efforts of research institutions, of governments and the instrumentalities of the United Nations such as the Food and Agriculture Organization (FAO), the World Health Organization (WHO), the World Meteorological Organization (WMO), etc., and not forgetting the international financial authorities.



ERODING WINDS ride unbridled across the barren desert flats. This tree whose roots search vainly for soil food and moisture stands on an island, the original height of the surrounding land. Tree roots have protected the soil under them from erosion by wind. (USIS Photo.)

Let us now look at some of the problems with which those charged with arid land development have to deal. I propose to list them under the following heads—water, soils, plants, animals and man, and give what must obviously be a very sketchy outline of some of the salient features of each and then come to a conclusion.

Water is placed first for obvious reasons and adequate information about the water resources of a region is essential to a safe usage of that water for full development in food production, domestic use and industry. In the desert one conserves every drop of water for the maintenance of life, in great urban centres we turn a tap and water flows, but sometimes restrictions are placed on turning those taps. In other lands the fresh water from great mountain ranges flows several thousand miles to the sea and constitutes a fresh water delta of tremendous size in the ocean.

Whence comes the supply, great or small? The answer is rainfall and this is the beginning of what is called the hydrologic cycle. Some of the rain soaks into the ground, some runs off in streams, some is evaporated and some transpired by vegetation. That which is evaporated or transpired by plants, like stream

(Cont'd on next page)

Dr. B.T. DICKSON, British-born Australian botanist, is one of the leading world authorities on plant adaptation and biology of orid lands. He joined the Commonwealth Scientific and Industrial Research Organization in Australia, in 1929, and became the head of its Division of Plant Industry. The above article is a slightly condensed version of a paper entitled. "The Challenge of Arid Land Research and Development For the Benefit of Mankind" *presented on the symposium of the International Arid Lands Meetings in Albuquerque, New Mexico, USA, under the sponsorship of the American Association for the Advancement of Science. It will be published in unabridged form by the Association as part of the volume of proceedings.*

CONQUEST OF THE DESERT *(Continued)*

waters, may travel great distances, but ultimately it again falls somewhere as rain, snow, hail, fog or dew.

In tropical areas rainfall may actually be beyond the capacity of man to use, as with the Amazon, but in arid and semi-arid areas rainfall is low and every effort must be made to conserve usage to the best ends. This applies even when an arid area is using imported precipitation as in Egypt, where the Nile valley is dependent in the main for its supply of water on the rainfall in the Abyssinian highlands.

One of the first problems in the hydrological cycle of arid areas is that of accurately measuring precipitation, because rainfall is low anyway. It can be very local and extremely sporadic, this erratic distribution, both geographically and in time, making for considerable discrepancies in accurate measurement.

It is well known that advanced civilizations formerly occupied what are today arid regions. Excavations show the remains of reservoirs, canals, fortifications, and human habitations, presuming an intensive and extensive cultivation by a large population. Such is the case in India, Pakistan, North Africa, the Near East, and even in the desolate region of Lob Nor in Central Asia there are remains of oasis towns and irrigation works. The disappearance of these civilizations may have been brought about by severe climatic changes or by the doings of man not for the benefit of mankind.

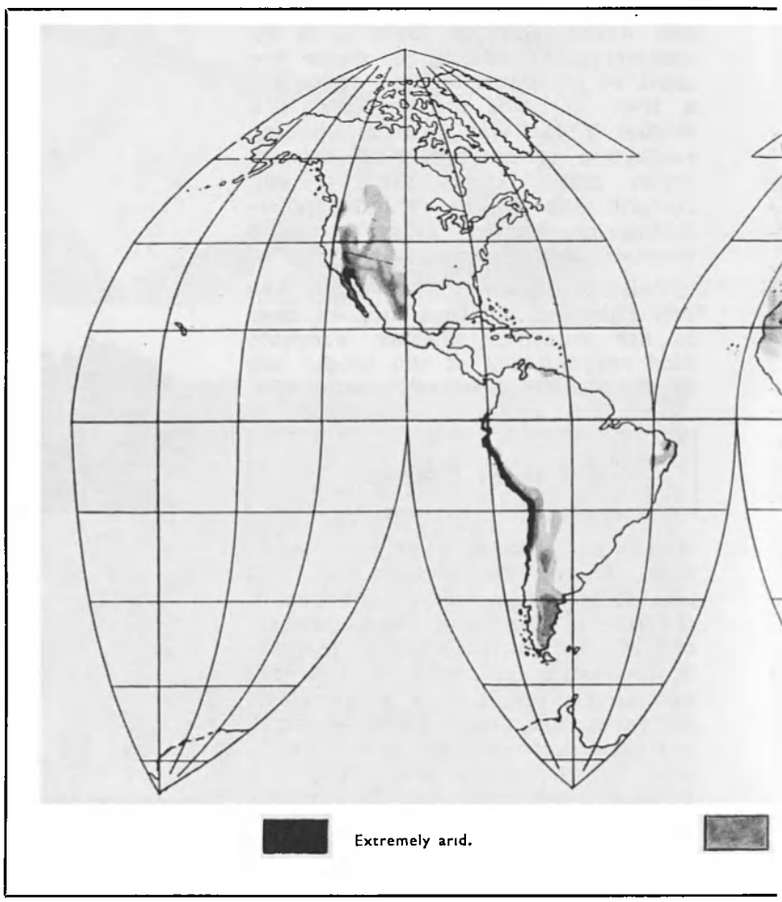
M. Jean Tixeront, of Tunisia, in asking whether it is possible to forecast weather over long periods, points out that we haven't yet sufficient reliable records, but states that in Tunisia they use one of nature's records in the growth rings of trees and one of man's in archaeological studies. The meteorological service of Tunisia studied the climate of Ain Draham from 1736 to 1955 by examining the growth rings of an oak tree. The inference drawn was that from 1736 to 1790 there was significantly more rain than later and this seems to be confirmed from historical documents which refer to abundant crops in the eighteenth century.

Tixeront considers that a study of the ruins of Arab and Roman irrigation works, of historical texts, of the continuity of cultivation methods and the cultivated plant species indicates that the climate is stable and has not become decidedly drier. Similarly it was reported at the Unesco Arid Land conference in Jerusalem in 1953 that all the historic, botanical and archaeological evidence pointed to little change in climate during the last eighty years or so in Israel and India.

Tixeront points out that droughts do occur and we ought to become aware of their statistical probability and makes a plea that we study all the climatic factors which may lead to the development of drought periods, as conversely to flood times.

In practice, in Tunisia information from historical and archaeological sources has been used to good effect. The planting of olive trees at the same spacing as used by the Romans in dry farming is successful today. So, too, wells, cisterns and irrigation channels of Roman origin give a guide to modern siting and use.

In semi-arid and arid areas transpiration and evaporation (or to put them together as Dr. C. W. Thornthwaite does under the term evapotranspiration) constitute the major factor in the recirculation of rainfall into the air, but it is notably difficult to measure satisfactorily because of differences in plant cover. It is becoming clearly evident that in some instances an increase in crops or pastures or tree cover may severely tax the capacity of ground water supplies and in general a balance has to be struck between the needs of crops and the water supply.



Experiments in South Africa indicate that only about three percent of rainfall goes lower than the root zone of veldt grasses. Phreatophytes, or plants which grow their roots down to the water table like alfalfa, are notable for their efficient transpiration; indeed I have on occasion recommended the use of alfalfa to drain waterlogged orchards in irrigated country. Worthless phreatophytes may waste millions of acre feet of water in an arid country.

In order to assess the water requirements of an area, wherever it may be, some way of measuring evaporation and transpiration must be used, yet strange though it may seem we have not yet achieved exactitude even in reading evaporation pans. Dr. Thornthwaite, who has devoted his scientific life to the study of climate, has proposed a method of estimating the water need of a region so that it is possible,

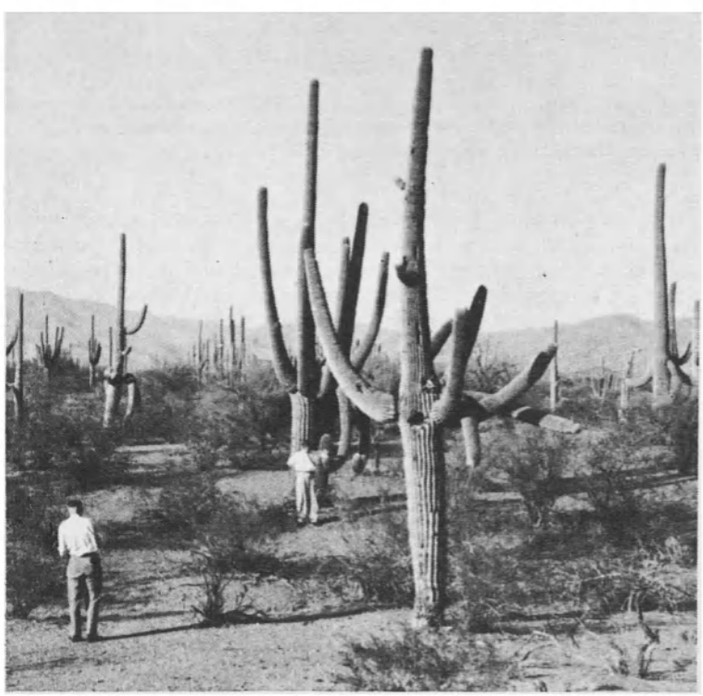


Photo J. Swarbrick

EMBLEM OF ARIZONA in the U.S.A. is the Saguaro or monument cactus. These giant plants bear edible crimson fruit which were dried and ground into flour by the Indians. Cactuses shown here, dwarfing visitors to Saguaro National Monument, Arizona, are about 200 years old.

knowing the rainfall and the evapotranspiration, to determine how much additional water, if any, is needed by way of irrigation.

Latterly, specially designed soil tanks four square metres in area and seventy centimetres deep, in which plants can be grown under field conditions, have been set up in a number of places, each tank being surrounded by a large buffer area to ensure greater accuracy in results, but not enough are yet in use to give the range of variation from one area to another. Meantime Thornthwaite and his colleagues have come to the conclusion that the computation of potential evapotranspiration for any place can be done from data on air temperature and latitude alone. With this it is possible to determine the water needs of an area and as it were keep accounts whereby the most economical use may be made of irrigation water.

Having briefly referred to rainfall, using that as a general term, we may naturally turn to what happens to the rainfall apart from evapotranspiration. Some infiltrates the soil and other layers and goes underground where it may be stored or move slowly in suitable layers gradually towards the sea. The most generally used method of determining infiltration is to examine the data of the use and fall of water in wells, although today radio-active isotopes are available to make evident the movement of water through permeable strata. There are in the United States of America about seven thousand observation wells, and approximately five percent of these have automatic recording equipment.

The examination of an area for underground water in the first place calls for geological knowledge and the use of geologists to make the survey with or without the aid of geophysics. By this means exact records would be kept of all the wells or bores put down, the strata through which they went down, the quality and quantity of the water, and so on. Such a survey would enable estimates to be made of the total volume of the underground supply, of its area and depth in a confined source, or of its flow if unconfined, and the region of flow in the aquifer.

Below the Nile there is an underground river (aquifer) about 560 miles long reaching from about 80 miles south of Luxor to about 70 miles north of Cairo. According to Mohamed El Sayed Ayoub, one-time Inspector-General for Nile Control, the mean width of the stream is 10 kilometres, the strata of sand and gravel in which it flows ranges from 100 metres to 300 metres in depth, with a water storage capacity of nearly 500,000 million cubic metres, and the water takes nearly 100 years to arrive at the head of the delta. Each year 1,400 million cubic metres is planned to be used on 25,000 acres of a new irrigation project, about another 1,000 million cubic metres are used by plants and nearly 4,000 million cubic metres flow into the delta unused.

The great aquifer under the Nile and the Nile itself receive their water from distant sources, but were they to rely on local rainfall for the infiltration and stream flow they would be dry each year for six months.

I would like at this stage to tell you briefly the story of another great arid area which is being reclaimed, the reclamation of which illustrates regional organization of the order of the U.S. Tennessee Valley Authority. I refer to the Thal desert area in western Pakistan. It consists of a triangular area of nearly five million acres with a base of 65 miles along the Salt Range to the north, and a length of about 175 miles to the apex at the south, and is in the Punjab between the Indus, Jhelum and the Chunab. Tradition, supported by geological evidence, has it that the Indus formerly flowed down the middle and deposited huge quantities of sand and silt and later changed its course to the west. The superficial sand dunes arise from fine material blown from coastal and desert regions of Sind and Rajasthan.

The vegetation consists of low brush and scant grass, on which camels browse. There are no indications of early occupation, such as are found in other parts, prior to the 14th century, when a few tanks of about an acre each were constructed by the Emperor Sher Shah Sun.

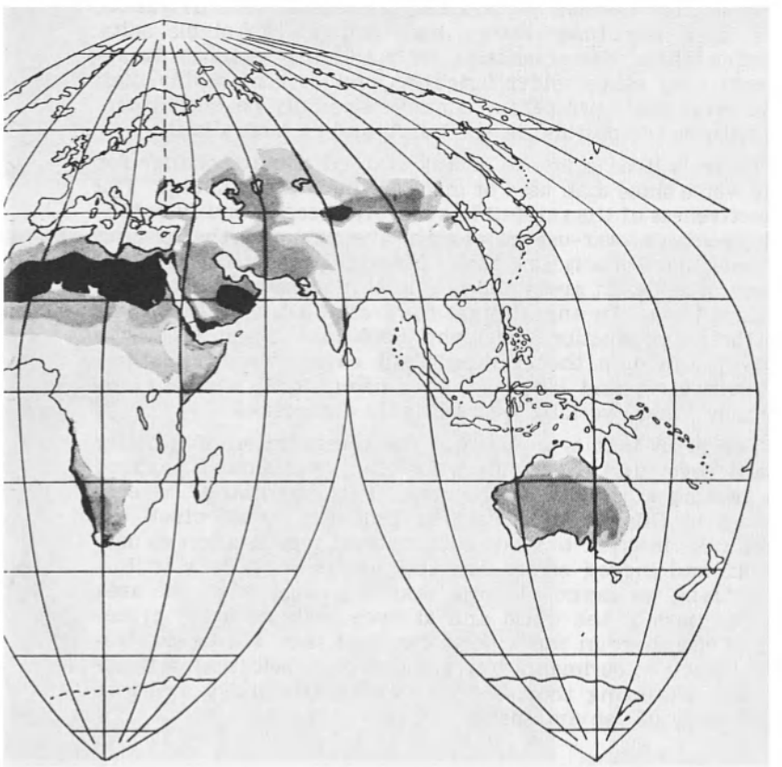
The question of developing the Thal area was first considered in 1870, but nothing was done until 1901 when a Colonization Bill authorized the construction of a canal to the Shamlat area. However nothing was done until 1936 when the distribution of the waters of the Indus and its great tributaries was considered. Work on a Thal project was begun in 1939 but held up because of the war, and channels were filled up with sand when in 1947 the flood of refugees from India moved into Pakistan. Of these 250,000 are being settled in the Thal.

In August 1949, the Thal Development Authority (T.D.A.) was established, to be responsible for the full development of an area of 834,500 acres, with an area of 638,000 acres to be developed by private enterprise with the assistance of the Authority.

It was believed that the agricultural development of the area and the establishment of villages and small towns throughout the area needed the balance of industrial development, and so today there are sugar mills, cotton textile mills, a woollen mill and a cement factory in the area. Some 640 villages have been established, each with forty or fifty houses on a total of 100 acres, with a green belt all round each village and a timber area of 50 acres alongside. Each settler is allowed 15 acres of land at not more than a mile and a half from his village, to cultivate satisfactorily.

The authority of the T.D.A. originally covered the million and a half acres commandable by canal for irrigation, but in 1953 a wider scheme *(Cont'd on next page)*

6,400,000 ACRES OF UNFARMED LANDS



One quarter of the earth's land surface is desert or semi-desert. This represents 6,400,000 acres of unproductive land receiving an average of less than 10 inches of rainfall per year. From adjoining map it can be seen that many of the world's deserts have long fringes bordering the sea-coasts. Unesco is at present completing a special study of these coastal deserts (which total 18,500 miles in length) as they offer more immediate possibilities of reclamation once the large-scale distillation of sea water becomes a practical reality. Map published here is based on special maps prepared for Unesco by Peveril Meigs of the Arid Zone Commission of the International Geographical Union.

Fresh water from the sea

was examined for parts of the three and a half million acres not commanded by canals. In certain belts masonry wells have for years been used to supply water for small holdings. The aquifer consists of sand layers with a water table at 40 to 60 feet in ample quantity, and so a tube well scheme has been initiated. How successful this will be remains to be seen because percolation is heavy and evaporation with summer temperatures up to 120° F. is high, but it is hoped that each well can irrigate 150 acres. Early last year Australia supplied tube wells to the T.D.A. under the Colombo Plan.

Before leaving this very sketchy description of a brave project I think it is safe to prophesy that in perhaps a decade there will be need to study a salt problem in parts of the Thal, and FAO is already at work in Pakistan on this problem in the Indus valley.

Mediterranean - Dead Sea Canal ?

In arid and semi-arid areas where the need for recharging the underground water is acute there are often long periods of no rain, interspersed with short bursts of storm rains with extremely rapid run-off, carrying astonishing quantities of surface material of sizes ranging from silt particles to boulders. These storm waters are gone in a relatively short time, as you know, and the problem is how to make good use of what are sometimes quite large supplies, by spreading and slowing down the rush of waters, by the use of dams and tanks, by selection of the site for percolation, and so on.

I referred a moment ago to the possible development of salty conditions in some of the irrigated land under the T.D.A. Rainfall is relatively free from salts and where rainfall is adequate for agricultural production excess soluble salts in the soil are leached away in the drainage water, but where rainfall is low leaching is reduced and salt accumulation can occur. All irrigation waters contain salts dissolved from rocks and soils through which the water moves.

Some years ago Scofield studied irrigated areas in the southwest United States and described the salt balance as the relation between the amount of salts being delivered in irrigation water and the amount removed from area in drainage waters. This concept backed by suitable methods for its application may be valuable in preventing salting and in remedying existing salt conditions.

Dr. H. E. Hayward, of the U.S. Salinity Laboratory at Riverside, has prepared a most comprehensive review for UNESCO of research on plant growth under saline conditions. In it he refers to the classification of saline and alkali soils, the quality of waters for irrigation, the physiological bases in plants for salt and alkali tolerance, the effects on plant growth and on seed germination and then succintly reviews the position in Australia, India and Pakistan, South and Central America and North America.

As human, animal and plant bodies are so largely made up of water it is little wonder that the ability of man to live is dependent on having plenty of good water. I referred earlier to the relationship between population and food supply. The same sort of relationship obtains between population and water supply. It is little wonder then that men's minds turn to those seemingly inexhaustible supplies of water, the seas and oceans, and wish it were economically feasible to desalt sea water in immense quantities.

On one occasion a sincere good wisher asked me whether it would be possible to construct a canal from the Mediterranean through the Negev desert to the Dead Sea using desalted sea water for irrigating the desert and raising the level of the Dead Sea waters with the drainage. Well, the answer is that success in producing large quantities of fresh water economically from salt water is not just around the corner. There is no magic wand, but research is going on in many parts and there is little doubt that the day will come when in some arid areas it will be possible to provide desalted water at lower cost than, for example, water transmitted over great distances.

Dr. Everett Howe, of the University of California, prepared for UNESCO an excellent summary of research on the utilization of saline water and Sheppard Powell, a member of the Advisory Group to the U.S. Secretary of the Interior, has reported on the Saline Water Conversion Programme. This programme was established by the Congress of the United States under Public Law 448 and the research projects financed by grants in aid under this enactment are already highly productive, especially in assessing the merits and costs of producing fresh water from saline supplies. The Saline Water Programme is due to end July 1957, but I am sure we hope that it may be extended beyond that date.

I now come to a consideration of that which forms the base on which food production on the scale for world needs takes place—the soil. It is not proposed to go into any detail about arid soils. Suffice it to recall a few characteristics such as their low content of organic matter and so of nitrogen, the fact that they are more usually alkaline than acid and so may develop permeability problems with irrigation, and their sometimes rather high content of soluble salts. Despite these characteristics, with suitable fertilizer treatments crop yields under irrigation can be remarkably high and large scale prosperous communities may be established, as witness the position in the U.S.A. and in Australia.

There is little evidence of any marked climate change for the worse since man used or misused the land for living. The effectiveness of the rainfall has however been seriously reduced by man's over-use of plough, the axe and the grazing animal, particularly the goat. Marginal areas have become man-made desert areas and it is in this sense that the desert is advancing. In any attempt to re-establish marginal areas for better production and living conditions it is necessary to survey and map the existing plant cover, whether natural or cultivated, and land use, as is being done, and/or planned, by F.A.O. working with national authorities.

The main task is to attempt the regeneration of a better plant cover and to do this while the population is engaged in gaining a living from the area. It is essential to have as guides in this work enclosed or protected areas which are ungrazed, in order to study such natural regeneration as may occur and indeed sometimes the results may be startling. One thing we cannot do, and that is go over from one area in one part of the world and at once begin to apply procedures elsewhere in the expectation that they will be successful. Much experimentation is needed in selecting suitable plants, in getting them seeded, germinated and growing in these very old environments.

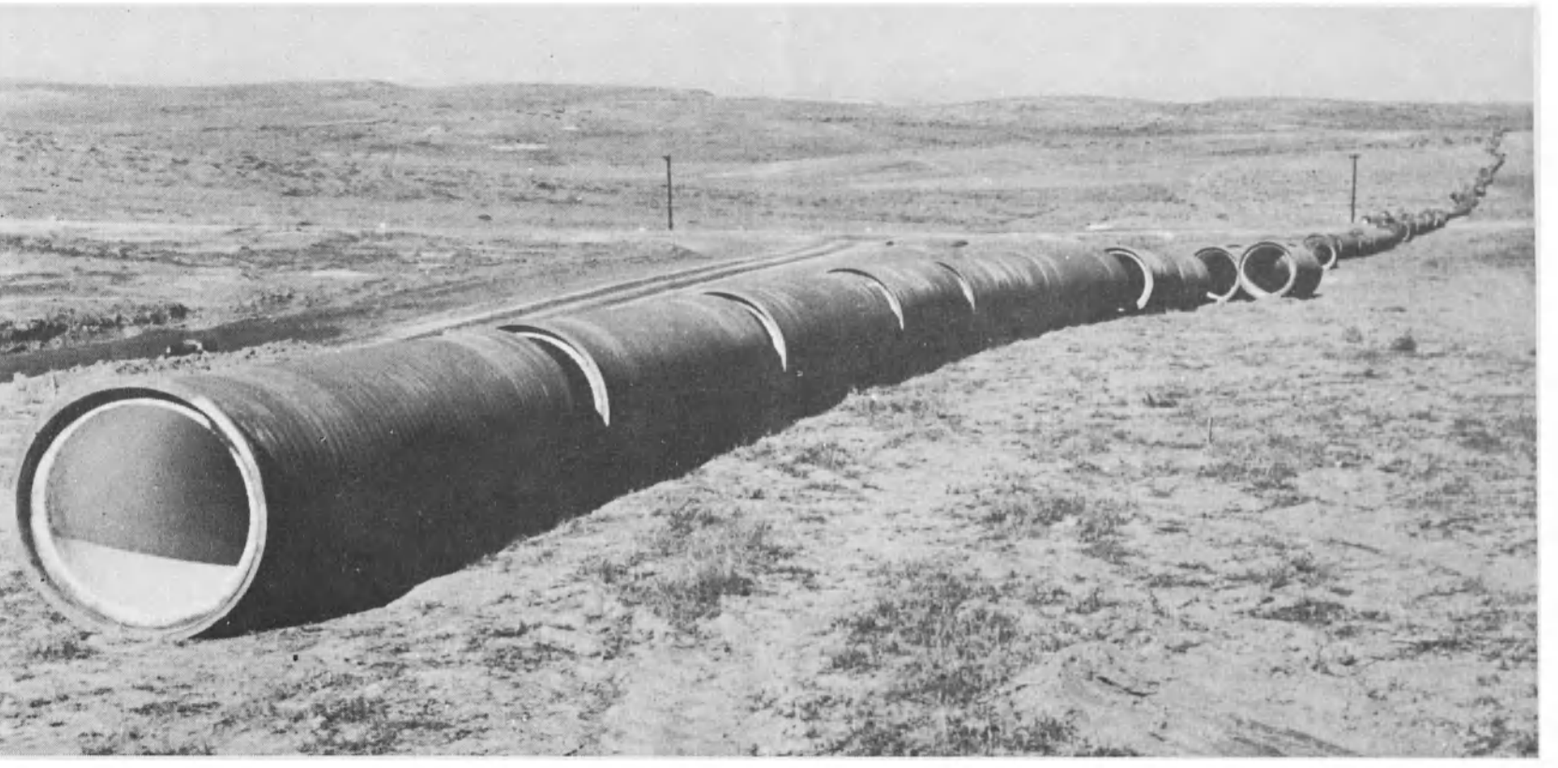
Land of imported plants

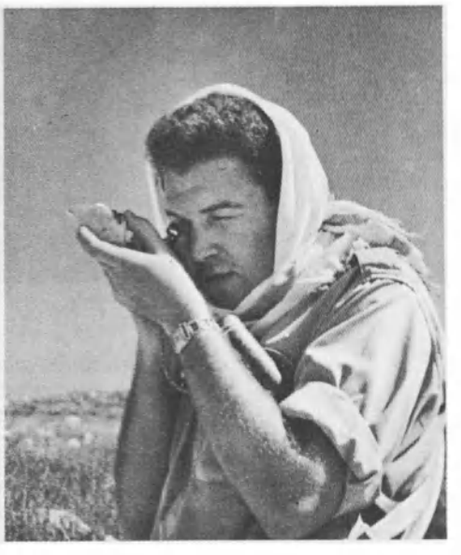
It is dangerous to disturb the land surface more than necessary even with good intent because of the possibility of soil removal or seedling scarification by the sand-loaded winds which blow in the hot season. I have seen this in the Thal desert of Pakistan where we are making trials with a number of plants. It seems to me that the provision of some shelter from these searing winds is essential and this can begin round nursery areas and in strips suitably placed across the prevailing winds. The limitless horizons of the desert are very interesting to write about but they are no good for proper land care.

Now, I come from a land where it has been necessary to introduce and establish every kind of plant food which you can think of for man and his animals, with the exception of the native grasses and top feed dry climate trees like the mulga (an Acacia). We have successfully introduced every kind of fruit and vegetable which can be grown anywhere and we are still testing many grasses and legumes. The same is true of the U.S.A., where I think trial introductions from all over the world total more than 65,000.

Oustanding with us has been the success of subterranean clover, which has meant millions to sheep men in southern Australia. *Phalaris tuberosa* and rye grasses (*Lolium spp.*) in the south, *Censhrus spp.* in the west and Rodhes grass in Queensland are other

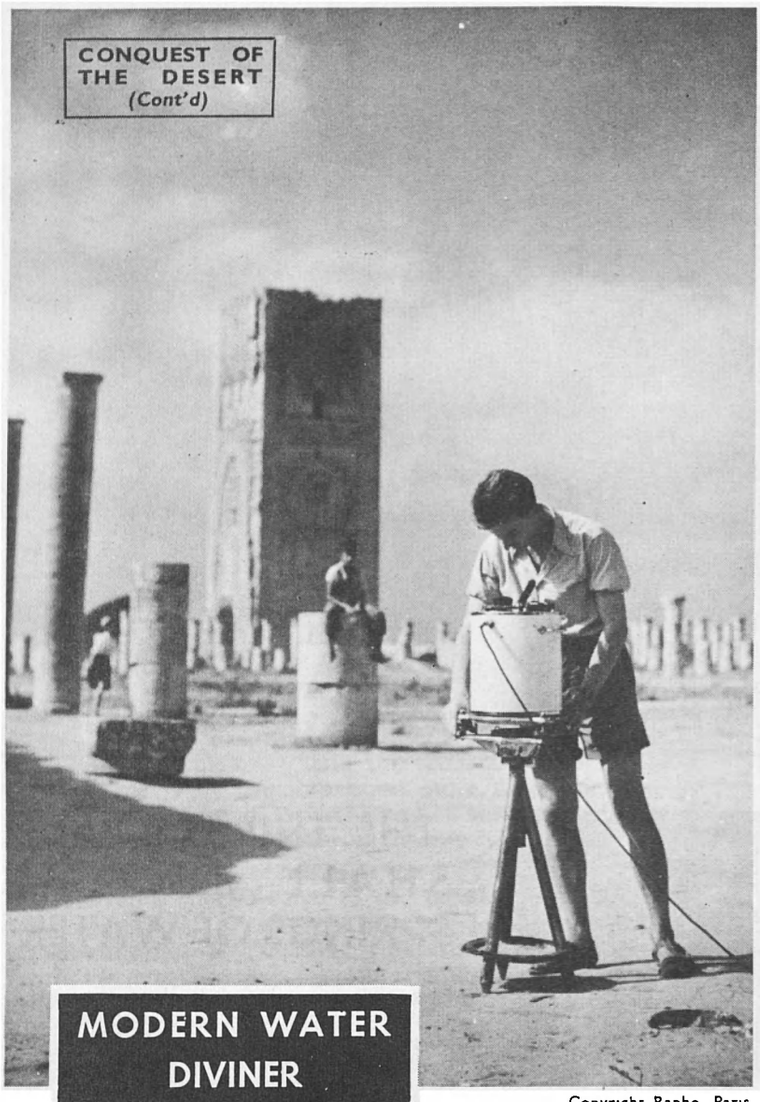
(Cont'd on page 12)





'THE THIRSTY LAND SHALL BECOME SPRINGS OF WATER'

Large-scale research and development work to make the barren desert lands blossom in the Negev region of southern Israel has been vigorously pushed ahead for the past several years. A pipe line (above) crossing the entire Negev is being constructed to bring water from the north to the parched lands of the south. Scientists (left and below) prospect for underground water sources by studying rock and soil structure. Extreme left, research worker experiments on water needs of plants at Hebrew University laboratory, Jerusalem. In 1952 an international symposium of arid land scientists was held in Jerusalem under Unesco's auspices to examine the latest findings of desert research in different parts of the world. (Unesco Photos)



MODERN WATER DIVINER

Underground water survey is made near Rabat, Morocco, (above, left) by gravimetric method. Instrument records variations in gravity and reveals subsoil structure. Above, right, irrigation canal brings water to Moroccan date groves.

Copyright Rapho, Paris

Belin, Morocco.

illustrations. But the U.S.A. and Australia use alfalfa, called by Australians lucerne, the American name being nearer the Arabic which means the good plant. I refer to this to illustrate the possibilities of plant exploration for grasses and legumes particularly in old arid areas. There is much yet to be done in this field.

It is obviously necessary to learn what are the physiological factors which enable desert and near-desert plants to survive long periods with limited water supply under conditions of excessive insolation, very high day temperatures and low night temperatures.

Colonel Omar Draz, Director of the Desert Range Development Project in Egypt, has referred to the need for a thorough understanding of the ecological, genetic and physiological bases which will enable the selection of plants and animals most suited to arid conditions, and has drawn attention to the importance in animals of heat tolerance and heat dissipation, about which much is still to be learned. He has stressed the idea that it is shortsighted to look down on local breeds which have become adapted to the conditions of living in the environment.

Whatever research work is done in any or all of the fields we have so far considered, the end result should be for the benefit of man and it is appropriate therefore to think at this stage about man himself, his well-being and living conditions. One striking feature of man in the desert is his nomadism, and while it may always be that some movement of flocks must occur to and from grazing areas it does not follow that the shepherds remain nomads. It is unnecessary to do more than remind you how very different the lives of men, women and children are under nomadic conditions from those which you enjoy in a dry climate. Any changes in modes of living must mean great social adjustments for those people.

W. S. S. Ladell, Director of the Hot Climate Physiological Research Unit in Nigeria, dealing with the influence of environment in arid regions, points out the wide range in temperature which man has to live under, as for example at Basra where the mean monthly minimum varies from freezing to 83°F and the mean monthly maximum from 67°F to 109°F. Under these conditions there is also little cloud, and scanty vegetative cover so that the ground radiates heat, and dust-laden air radiates still more heat. With wind in addition, water loss from the body may proceed faster than physiologically desirable.

Ladell refers to heat acclimatization, by which is meant the physiological changes resulting in an improvement in work following exposure in a hot environment and considers that man can live under conditions more severe than occur in the hottest parts of the world. Protection from direct solar radiation is desirable in the form of a light broad-brimmed hat, or on a tractor a canopy over the driving seat (1).

Good housing is essential—cool by day and such as to give adequate protection at night—and in this respect the thick-walled, small-windowed, pise houses of the Near East, Pakistan and India are types.

Desert dwellers may suffer from prickly heat and from malnutrition and vitamin A deficiency which leads to slow healing of wounds.

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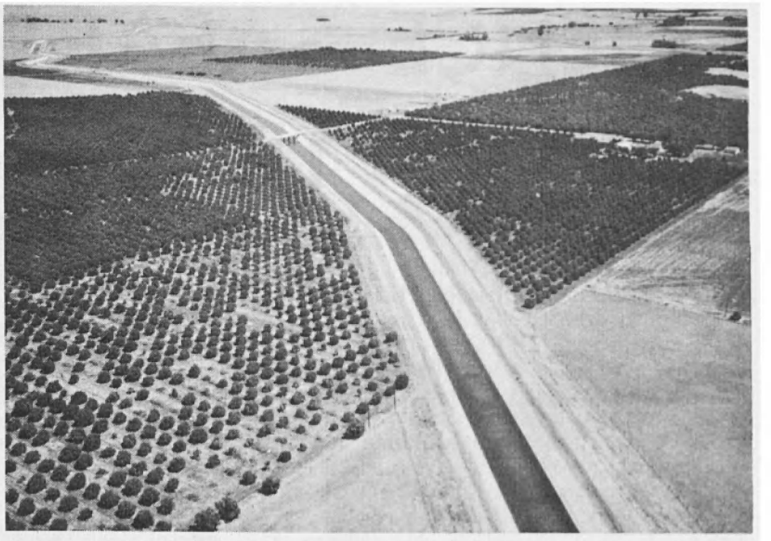
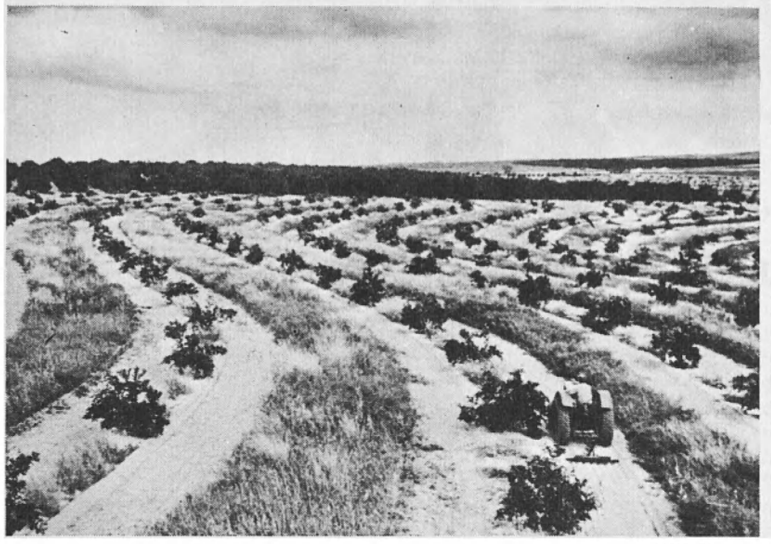
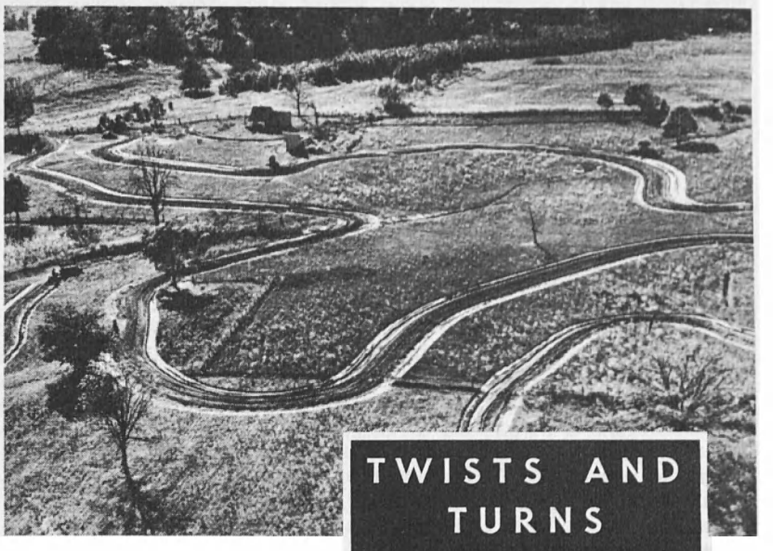
(1) For an article by Dr. W.S.S. Ladell on the Myth of the Tropics, *See page 58.*







USIS Photos.

TWISTS AND TURNS

Dry lands in the United States have become miraculously productive thanks to large-scale irrigation programmes. Photos show landscapes now marked by curving channels, contour ploughing and terracing to prevent soil erosion.

Water is the essence of life and it seems a pity that because of religious beliefs or tradition desert dwellers do not take to the use of galvanised iron tanks to store roof water.

We who live in comfort find it hard to realize what life is like without electricity or gas, without water in pipes, without refrigeration and radios, air conditioning in buildings, good roads and fast cars and so forth. But many thousands live where hydro-electric power is not available nor where fossil fuels like coal and oil can be used. So we turn to such sources of power as wind and sun.

Successful wind-driven generators up to 70 kW capacity are functioning in the United Kingdom; and much thought is being given to automatic regulation in variable winds in order to make the fullest use of wind power. It is most important to choose the right site for a windmill.

The use for wind power to pump water either directly or through the use of electricity should result in saving bullock power and thereby acreage for human food.

Solar energy has already been put to work for cooking and heating water and we saw demonstrations of equipment in action at New Delhi, India, last November. The problem is to reduce cost to within the means of the average Indian. Here in California hot water heaters have been installed on the roof with insulated hot water storage tanks.

Considerable thought and experimentation is being devoted to the possibility of developing a solar engine. Dr. Abbott of the Smithsonian Institution has long pioneered in this field.

In any scientific work it is first essential to survey the field. In this case it is a survey of the fields, and so it is a highly complex operation calling for teamwork of the highest order. I do not decry individual effort, indeed some of the greatest contributions to knowledge have been made by the Newtons and Einsteins. But in the title of the address allotted to me "The Challenge of Arid Land Research and Development for the Benefit of Mankind" it is impossible to avoid the inference that here we must have team work, and that team work should be between individuals, between universities and research institution and between peoples—in other words between United Nations Organizations.

Particularly does it seem appropriate that we who belong to those sections of mankind that enjoy the highest standards of living should see a plain duty to help in every way possible to benefit the less well-off sections of mankind.

I often think how wasteful it is that the billions of money used in defending part of mankind against possible aggression by another part of mankind could not be spent in research work of this sort for the benefit of mankind. Imagine our young folk being called up for service and electing to serve for a period in one of the fields we have been discussing during these meetings. But that is Utopian.

It seemed to me that the title of this address required me to be a sort of missioner, and if I have succeeded in confirming you in a determination to support in every way you can the efforts of scientists, the work of institutions and above all the great work being done in UNESCO, FAO, WHO and so on, I am amply rewarded.

SCIENCE SAFARI IN THE U.S.A.

A VAST area of the United States is desert or semi-arid. Except for a few rich valleys in the northwestern corner, the western third of that agriculturally rich country, measuring almost 2,000 miles from northwest to southeast and 1,000 miles eastward from the Pacific ocean, depends on irrigation with waters from the high mountain ranges that run through it. The irrigated lands are miraculously productive, but irrigation can touch only a small fraction of the area. The Americans want to do something about the land that cannot be irrigated.

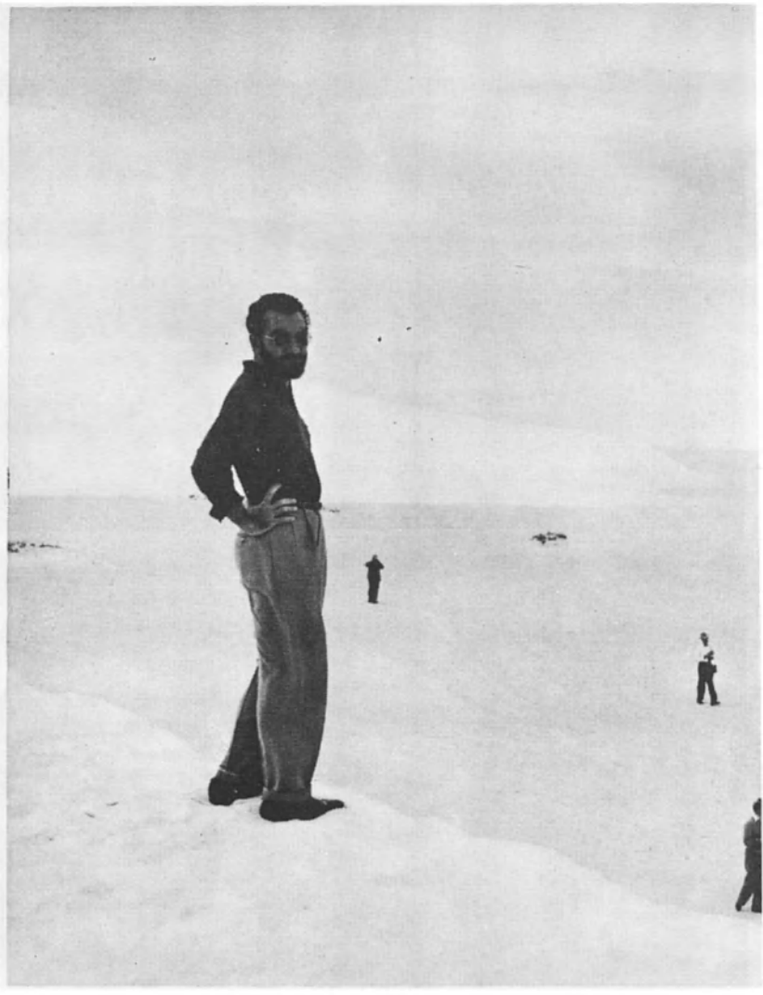
It was this that led the farmers and businessmen of the Rio Grande valley in the states of Texas and New Mexico to organize a three-day international conference at the old Spanish city of Albuquerque in New Mexico, attended by 64 arid-land experts from 26 nations and more than 400 American specialists. With the aid of Unesco, the American Association for the Advancement of Science and the National Science Foundation, the scientific sessions were held at the University of New Mexico during the closing days of April this year.

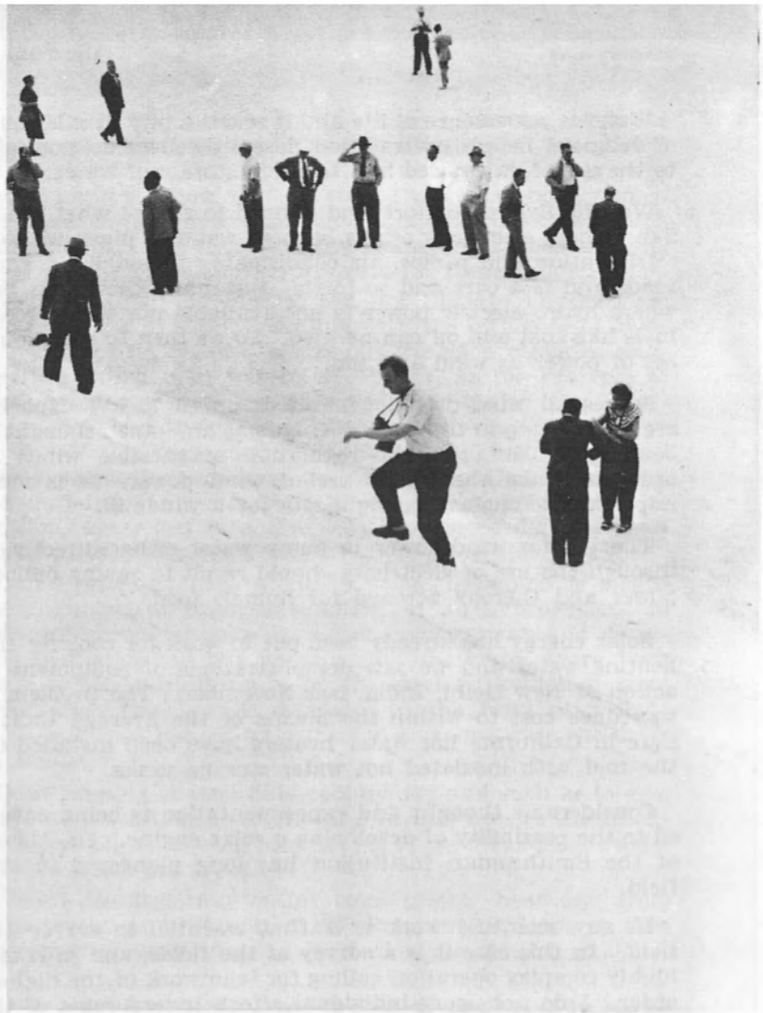
BUT the most effective feature of their plan was a two-day, 600 mile autobus caravan for 95 of the experts, including men from 20 other arid countries, who saw and studied desert conditions and exchanged experiences and opinions face to face. Never before has a desert been so expertly examined. One of the scientists wrote afterwards: "It was a time for relaxed exchange of ideas, for a birds-eye view of almost the entire range of arid-land problems in the framework of the lives and prosperity of the people of the area. It welded strong friendships which crossed many national boundaries and provided a common experience and background for future friendly co-operation between nations."

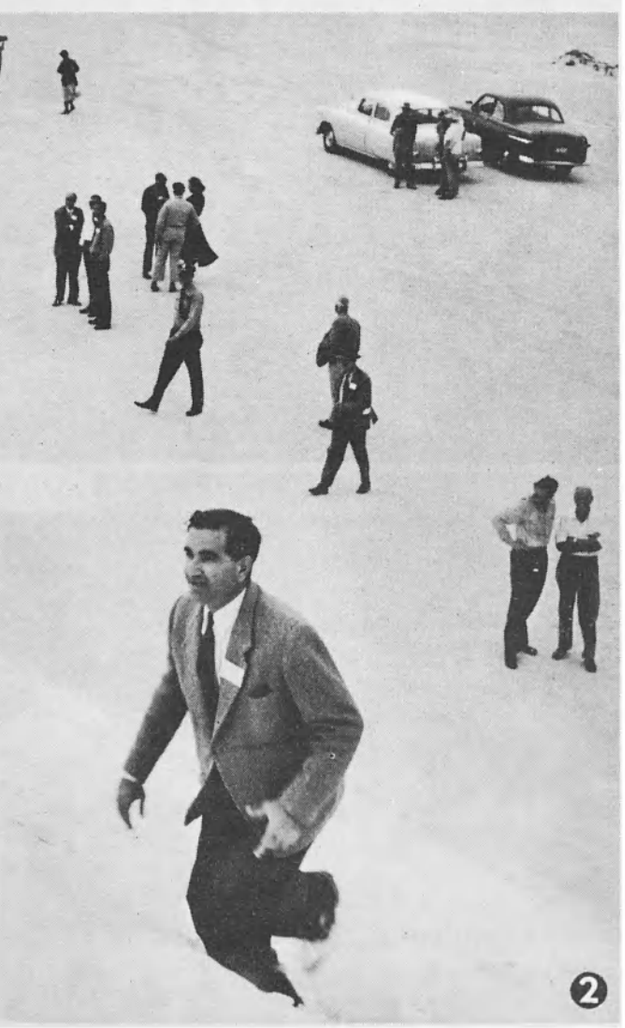
The expedition started from the city of Albuquerque on the Rio Grande, which is not grand, but is a mere trickle of water, and wound over a mountain pass into the undrained Estancia Valley where pinto beans are grown in large quantity—at the cost of pumping irreplaceable ground water from far beneath the surface. Then came an area of dry salt lakes that testify to ample rain in former times. Then to higher mesas where remains of ploughed fields and ruins of houses show how recently the desert has advanced. The stone ruins of the Spanish church at Gran Quivira show that the Spanish settlers three hundred years ago also failed where the native Indians had prosperously lived on the land for many centuries.

STILL farther south came the barest desert of all, the "malpai" or bad country formed by a flow of lava less than 1,000 years old that covers 127 square miles to an average depth of 70 feet. Following this came the unique "White Sands" and more and more desert. On the second day the caravan wound north from the city of El Paso up the valley of the Rio Grande through the irrigated farmlands and to the experimental desert ranch of the State College of New Mexico. Before returning to Albuquerque the expedition also examined the dam, lake and irrigation system at Elephant Butte which has been in operation since 1915 and shows what forty years can do in reducing the effectiveness of a river dam.

The photographs on these pages tell the story. The scientists do not look impressive or even scientific. And they did almost nothing to improve this land that they saw—at least, not yet. But these are some of the men on whom the future of the arid lands depends. Under the leadership of the Unesco Advisory Committee on Arid Zone Research, and after this extended intimate contact with each other, any benefit accomplished for one arid land will swiftly be extended to all arid lands—and that means to one third of the earth's surface and to the peoples of 37 nations or almost exactly half the member states of Unesco.

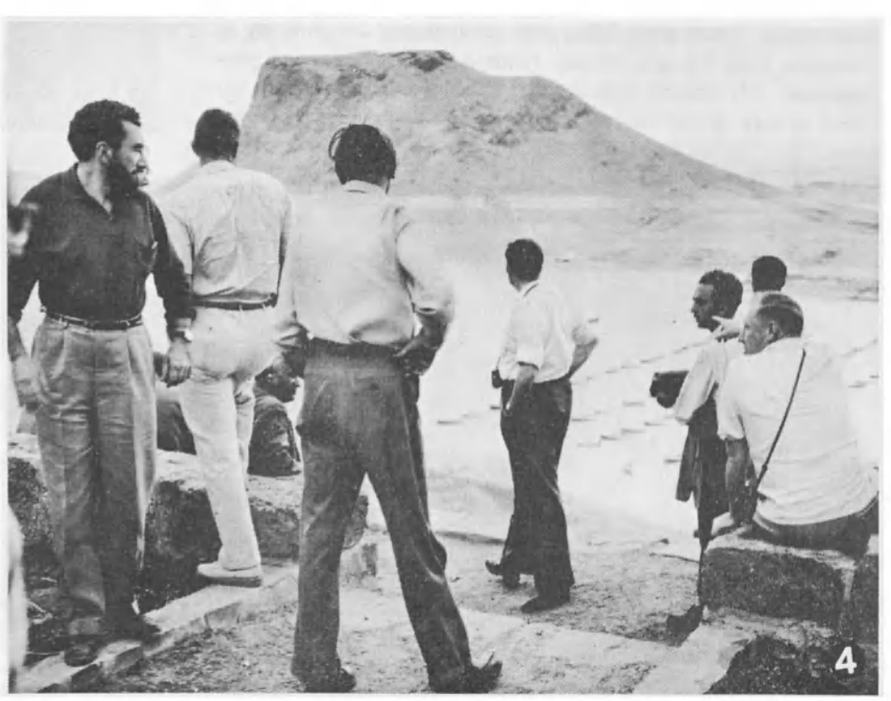






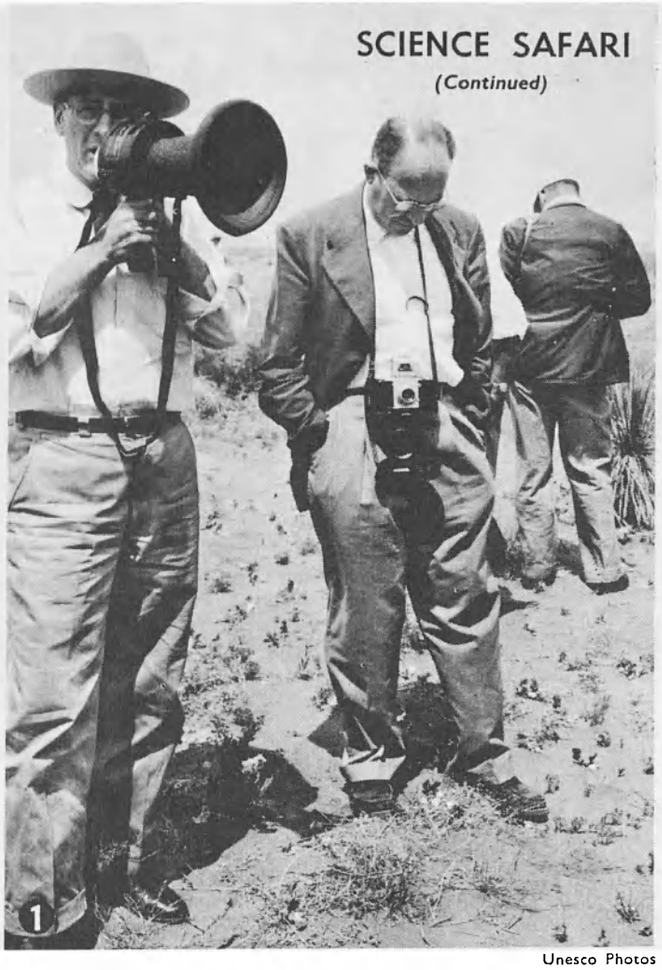
'WHITE SANDS'—WORLD'S LARGEST GYPSUM DESERT

White Sands, New Mexico, whose snow-like glistening sand dune formations cover 270 square miles, is the largest of the world's gypsum deserts. Long ago, deposits of gypsum in surrounding mountains were carried by rivers into a lake which once covered the entire area. As the climate became arid, the lake evaporated and the gypsum separated into crystals which the wind has piled into high dunes. (Photos 1 and 2) Scientists from many countries visiting White Sands during a field trip organized in conjunction with the International Arid Lands Meeting at Albuquerque, New Mexico, take to the clean, steep dunes like boys. (3) Dr. Albert H. Reid, of the U.S. Forest Service in the State of Colorado, and Dr. Pedro Armillas (with beard) Professor of Archeology at National School of Anthropology, Mexico City, inspect ruins of Spanish mission church built at Gran Quivira in 1640. Spaniards abandoned it 15 years later because of hostile Indian raids and crop failures caused by lack of water. (4) Scientists gaze across desert dam towards Elephant Butte —the remnant neck or conduit of an ancient volcano. The dam, on the Rio Grande, is forty miles long and irrigates 160,000 acres of good agricultural land. (Unesco Photos)



SCIENCE SAFARI

(Continued)

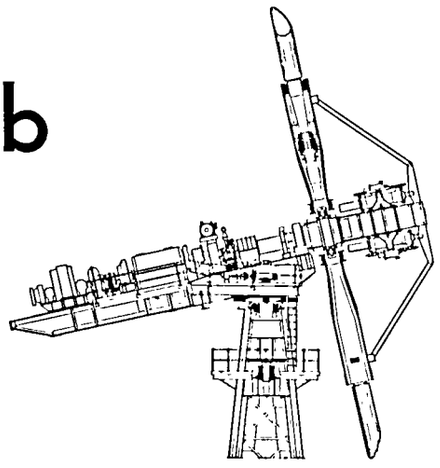


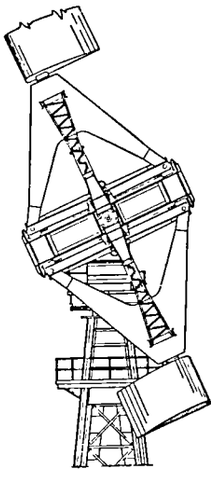
Unesco Photos

'AT HOME' ON THE RANGE

In the wide, dry New Mexico valley called Jornada del Muerto (Journey of Death) are the Experimental Range of the U.S. Department of Agriculture and Experimental Ranch of the New Mexico State College of Agriculture. During the past 20 years more than 100 varieties of grasses and other plants have been tested here. (1) Scientists from many lands listen to Mr. K.A. Valentine (using voice amplifier) of the Jordano Range, describing the results of 20 years of desert research. (5) Valliolah Vaziradeh, of Iran's Dept. of Agriculture, studies volcanic formation at Elephant Butte, across the dam on the Rio Grande. (3) Dr. Jens Clausen, botanist from California makes notes on conditions of plants while another scientist photographs the Jornada Range. (4) A single desert plant is interesting enough to dig up. Scientists from Ethiopia, Mexico, Pakistan and U.S.A. examine plant together. (2) Science caravan halts. During safari scientists studied strange formations and vegetation in the American Desert.

Old device in new garb





HARNESSING POWER FROM DESERT WINDS

by

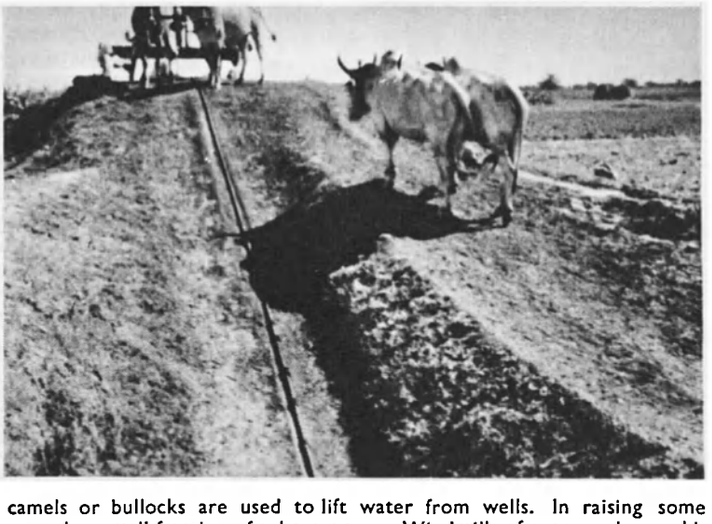
E. W. Golding

For centuries nomadic peoples have led a precarious existence in deserts, or semi-deserts. They wander about with their herds of sheep and goats—and sometimes camels—following the occurrence of spasmodic rains which bring forth a thin cover of grasses and other plants for pasture. This crop is quickly consumed and the animals browse on the foliage of such shrubs as manage to thrive on the treeless plains. This mode of life is indeed free and independent but it is hazardous. If the rains fail the animals, and perhaps also their owners, die of starvation unless they are lucky in getting away quickly enough to better-watered lands.

Although it is a method of using the sparse "agricultural resources" of the desert, nomadism is a sure way to keep it as desert. Vegetation never gets a chance to become established so as to provide shade and to retain the random rain which, on a bare surface, so rapidly runs away, with disastrous effects in erosion. In addition to this excessive grazing, the inhabitants themselves make conditions worse by cutting shrubs to provide fuel for their fires—for cooking and warmth at night when the desert is cold.

To transform such desert lands into areas which can support a population in more security and, later, to contribute something towards the food supply for the rest of the world—for desert soils are often fertile if they are adequately watered—much work will be needed. Man can sometimes exist without toil but he cannot improve his lot without it. Even though he works hard, however, he cannot, unaided by mechanical power, bring about much significant improvement.

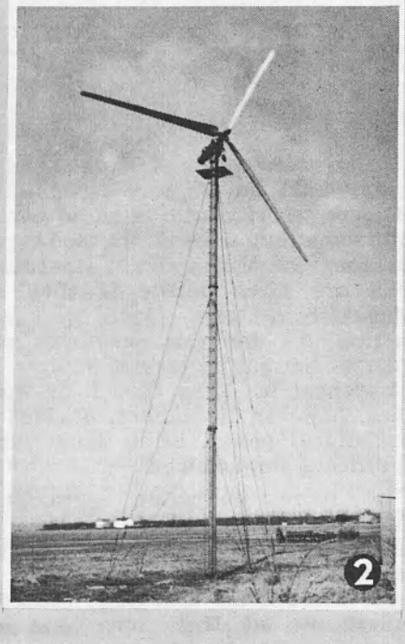
In more temperate agricultural countries, mechanization has been the key to development; high productivity demands machines to assist men to make the best and fullest use of their own *(Cont'd on next page)*

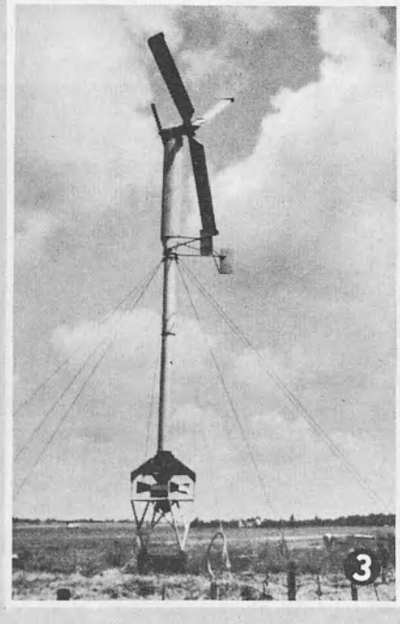


MUSCLE POWER V. A MODERATE BREEZE : In eastern countries camels or bullocks are used to lift water from wells. In raising some 600 or 700 gallons an hour from a depth of 30 to 40 feet, these animals exert only a small fraction of a horsepower. Windmills of even crude or old-fashioned design like those at Aden shown above can easily do same work driven by moderate breezes which blow in these areas. (Photos E. W. Golding)

Old device in new garb

(Continued)





efforts. Life is inevitably harder in the under-developed countries and the help of machine power is even more needed—power for water pumping, for cultivation, for corn-grinding and food preparation, for lighting, heating, refrigeration and for other domestic and agricultural purposes.

Whence can this power come?

It could, of course, be imported, but only at great cost. Electrical transmission from a distant power station to supply a scattered population, is likely to be matched in cost by that of transporting oil for local diesel-driven power stations. Maybe in the future, though how distant no-one can say with any certainly, relatively small "packaged" nuclear power plants will become available at an economic price but even the smallest of these will almost certainly be too large for use by isolated communities. In any case, are we to wait for many years before attempting to develop these areas in which water—the prime necessity—quite often lies at no great depth in the ground needing only some form of power to pump it to the surface for irrigation?

Search for power

THE question naturally arises "Are there any local sources of energy which could be used instead of attempting to bring in energy from outside the area?" Often there are. Abundant sunshine is a feature of many desert areas and this can be used for water heating, for the distillation of saline waters, for cooking and perhaps, later, for power when the problem of building solar engines at an economic price has been solved. The fact that bright sunshine in the desert supplies energy at the rate of about one horse power for every square yard certainly makes the idea attractive.

The wind often blows strongly enough to be used to produce power by means of some form of windmill. Very commonly during the daytime there is a breeze of 15 miles an hour (or even more) and we can easily calculate, for example, that at that speed the wind has a power of 20 horse power passing through a vertical area, 10 yards square, which could be swept by the revolving blades of a windmill. Not all of this power in the wind can be captured by the machine but if only one tenth of it were extracted it would be a very useful amount of power.

Aerodynamics helped

IN eastern countries one frequently sees water being lifted from wells by a camel or a pair of bullocks but, in raising some 600 or 700 gallons an hour from a depth of 30 or 40 feet the animals are exerting, on the average, a small fraction of a horse power. A windmill of even a very crude design could easily cope with this duty when driven by the moderate breezes which blow for several hours a day here.

During the last few years, encouraged by the rapid advances made during the war in our knowledge of aerodynamics, several countries have been giving much attention to the possibilities of wind power and national committees have been set up in England, France, Denmark, India, Israel, Holland and Spain. Present ideas go much beyond the simple water-pumping windmills and rather in the direction of generating electric power, on a significant scale, from wind-driven generators.

These will probably take a somewhat similar form to that of the small two-bladed windmills used to charge an electric battery for electric lighting in country houses, but they will be much larger.

The power in the wind is proportional to the cube of the wind speed so that if this is doubled the power is increased eight times. It is thus very important to choose the site for a wind power plant very carefully. Hill-top sites are best because of their good exposure and, even if the main purpose is water pumping, it may be well to instal the machine on a nearby hill, and to transmit the power to the pump electrically rather than to build it close to the well where the wind speed may be much lower. Any surplus electric

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Mr. Edward W. GOLDING is head of the rural electrification and wind power department of Britain's Electrical Research Association, London. He was responsible for setting up the first British wind-powered generating plant in the Orkney Islands. In 1951 he went to Israel under Unesco's technical assistance programme to advise the government on the possibilities of exploiting the country's wind resources. In 1954 he initiated a wind power survey in Haiti for the World Meteorological Organization.

power from the machine can then be used for other domestic or agricultural purposes.

In general, the present wind power researches aim at two main scales of use. The first is large scale, with wind-driven generators feeding their output of electrical energy directly into supply networks and so saving fuel which would otherwise have to be burnt in the power station to generate this energy. Wherever there are extensive electric power networks and there is sufficient wind—or high enough fuel costs—to make their use economic, these large machines could play an important rôle.

For the desert areas with scattered populations, the second scale, employing machines from about 10 to 100 kilowatts in capacity, is likely to be more applicable. Here there are no widespread networks and wind power must be used either alone or preferably assisted by solar radiation to fulfil the people's needs. It will be wise to use these two sources of energy for purposes for which each is best suited, e.g. the wind to produce motive power and the sun to provide heat for water heating and distillation and for cooking.

At least two wind power plants of about 10 kW capacity are already available and it is interesting to consider what amenities two or three of these machines, installed on a favourable site, could provide for a community of, say, 30 or 40 families. They could, for example, supply all the power needed for lighting, fans, radio and small-power domestic purposes; pump all the water for domestic use and, besides, could drive several water pumps, for irrigation, each equivalent to the efforts of a bullock team.

To give some figures, a suitably designed and well-sited 10 kW windmill could give an annual output of 15,000 to 20,000 units of electrical energy, each unit of which is capable of pumping about 5,000 gallons of water from a depth of 50 feet. As for energy costs, wind power compares favourably with that from oil engines (which may cost 3d. to 4d. per unit for fuel alone in a remote area) unless the wind speed is very low. Usually, however, it has not to compete with oil engines but with bullock power, and a team of 4 bullocks, with 2 men working them, can raise, in an hour, less than half the 5,000 gallons of water just mentioned. The bullocks are expensive to buy; they have a working life of only 5 or 6 years and each consumes some 10 to 15 tons of fodder a year.

It seems obvious, therefore, that the local resources of wind and sunshine should be exploited. Three main requirements must be met in exploiting them. Suitable machines must be built at a low enough cost. They must be installed at good sites to give maximum outputs, and their operation must be planned to make the fullest possible use of this output.

Whether it be from wind power or from solar radiation, the power supply is not continuously available and to store energy is expensive. Thus we must arrange to use it as and when it comes. Loads such as water pumping or water heating, which have inherent storage, must be used, keeping the storage by electric batteries to a minimum.

TURNING SAILS AND SPINNING PROPELLORS

Ingenious combined use of sun and wind power provides salt in the Tripoli region of the Lebanon. Wind energy harnessed by simple windmills lifts sea water to evaporating basins (sometimes several yards above sea level) where solar energy completes the operation, evaporating the water in each basin in about two weeks. Modern windmills (shown in column on left) reflect improved knowledge in aero-dynamics applied to wind energy research by many countries in search of increased power supplies. (1) Two types of German built windmills. (2) German machine used for research in Britain. Generator, located at top of supporting mast, is driven by three-bladed propeller. Placed at favourable sites, two or three machines of this capacity could provide enough electricity for a community of between 30 and 40 families. (3) French type wind-driven generator. Blades of propeller are hollow. In rotating they draw up air from bottom of supporting tube, through air turbine at its base, the air finally passing out of the blade tip. Turbine drives electric generator.

(1) Office Général des Eoliennes, Paris.
(2, 3) Photos British Electrical and Allied Industries Research Association.

Wind, sun and animals

Machines are being developed by engineering manufacturers in several countries but their designs must be based on adequate data from local observations. Sometimes it may be possible for crude windmills, sufficiently useful to serve as a start in development, to be made from local materials with, perhaps, reed or bamboo mats for sails.

There is an urgent need for meteorological data from these areas. but it must be obtained in suitable form for selected sites. We need information on wind speeds throughout the year, on the duration of calm spells, on the daily occurrence of wind and on sand storms and other local conditions. Often a place with a low average wind speed will be found to have quite usable winds for some hours in the daytime followed by calm periods at night.

A very important question which calls for study and for trials under practical conditions, is that of combining the power resources—wind, sun and animal power—to fulfil all the needs without storing the energy in batteries—except perhaps a little for electric lighting. Many purposes such as irrigation pumping, and corn-grinding, can be served at any time but power for lighting and heating is needed at night while cooking must be done by day.

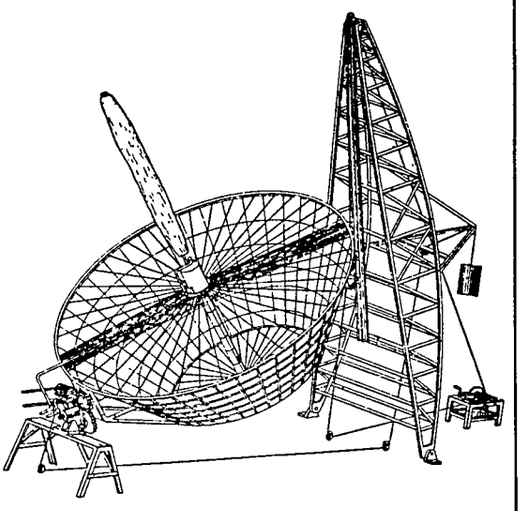
Heat stored in blocks

There are many possibilities to be considered as, for example, the storage of heat in solid blocks, in liquids or in melted crystals which give up their latent heat upon solidifying again; some agricultural loads can easily be met as power becomes available, while (if one dare mention it with reference to a desert area where it is so important to conserve vegetable matter) there is sometimes a little waste material which could be used as fuel for the small portable steam engines which have been developed in Great Britain. These engines can provide a small amount of power to fill up the gaps when there is neither wind nor sunshine.

One can conclude that the energy resources are often available to provide for the needs of remote communities capable of developing desert or semi-desert areas. Suitable machines are being built but what is now especially needed is intelligent siting and installation of these machines, and careful planning for their combined use, with guidance for the users until they grow accustomed to the new ideas which are involved.

Energy from the sun:

THE DESERT'S GREATEST RESOURCE



by Gerald Wendt

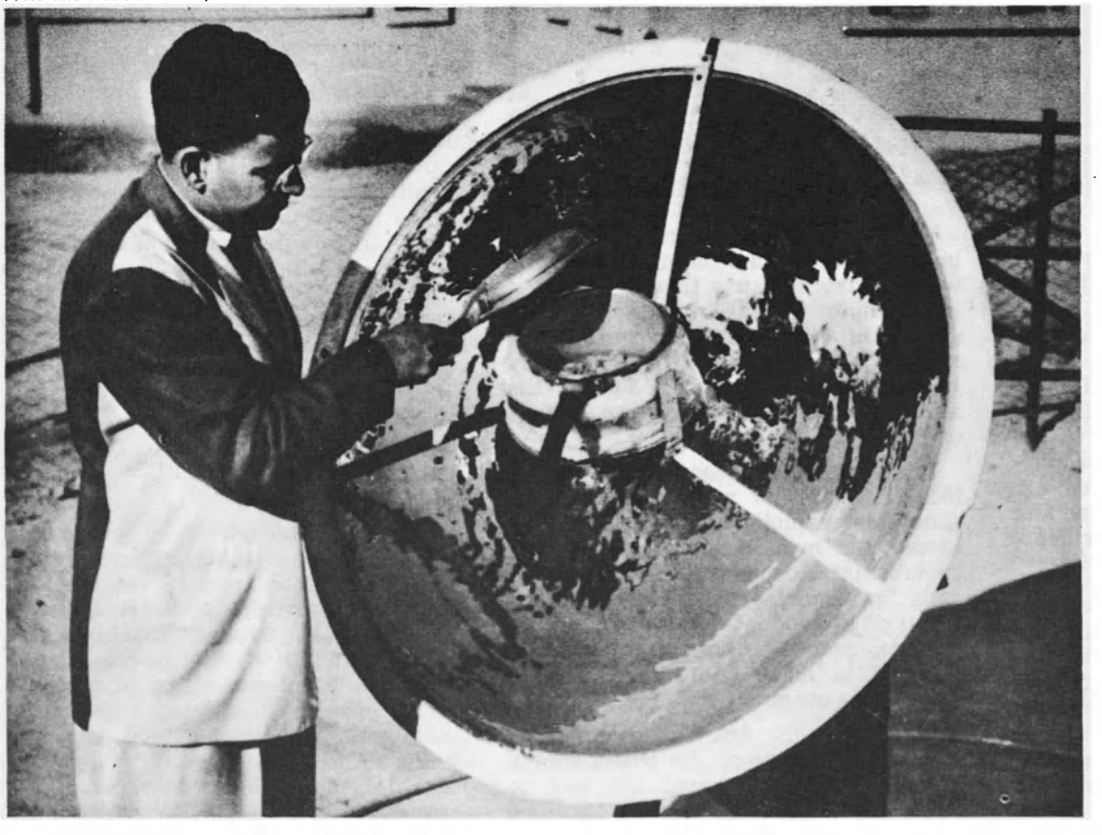
THE source of all life on earth is sunshine. When water is available green leaves use the energy of the sun to manufacture both foods and fuel. Each year the sun thus produces many hundreds of millions of tons of starch, sugar and, less directly, fats and proteins for human food. It makes no less than 10,000 million tons of wood each year. In past ages it has provided the many thousands of millions of tons of vegetation that are now underground in the form of coal. For lack of water, this does not happen in arid lands. The challenge persists, however, at least to utilize this great resource of the deserts as energy to replace fuel, if not to make food.

The amount of available energy in the form of sunshine is colossal—many times larger than can ever be used. The sunshine that falls in a day on 100 square meters of flat surface (an area 32.8 feet on a side, about as large as the roof of a small house) is equivalent to 558 kilowatt hours of electricity, to 146 pounds of soft coal, or 14 gallons of gasoline. If this could be used for power with an efficiency of only five percent, the sunshine on so small an area would provide 28 kilowatt hours or 38 horse power hours of work per day. The urge to find a way for using this energy is irresistible.

Sunshine may eventually be used on a large scale for the operation of factories. That day is far off, but the immediate need in the arid lands is for small power units for pumping water from wells and underground streams.

At the Unesco symposium on the utilization of solar energy which was held in New Delhi, India, in October 1954, Dr. Farrington Daniels of the University of Wisconsin, U.S.A., made this point in these words: "Let us be content with solar machines that have a conversion into useful work of only one to five percent of the sun's radiation that falls on them but let us insist on a simple low- *(Cont'd on page 22)* cost engine that does not need complicated

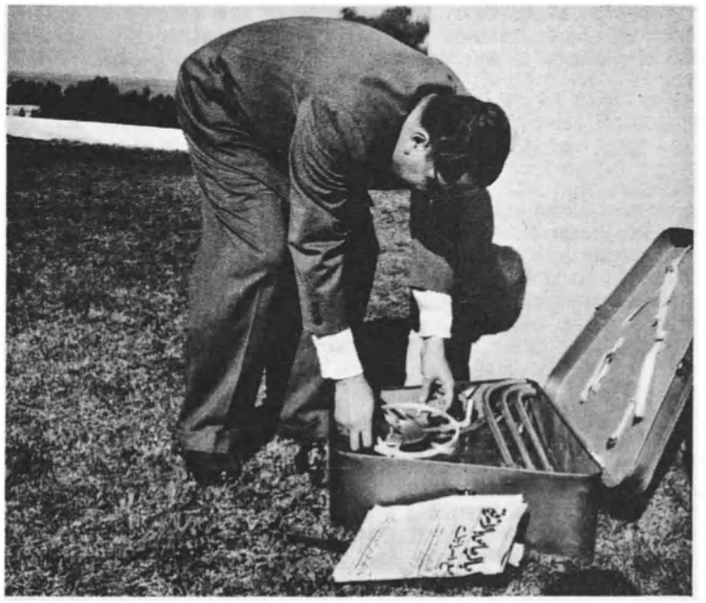
Press Information Bureau, Govt of India.

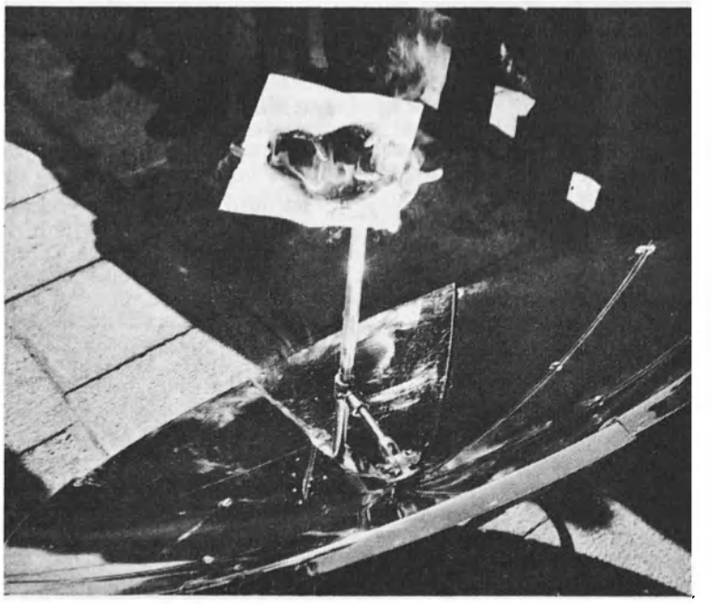


COOKING BY SUN POWER

Simple devices for putting the sun's energy to work in the kitchen are now being successfully developed in several countries. In the Middle East, a simple, compact solar cooker has been designed and perfected by a Lebanese, Dr. Tarcici. An Egyptian, firm expects to manufacture about 18,000 a year. Photos on opposite page show Dr. Tarcici demonstrating his solar stove. In India a simple solar cooker developed by the National Physical Laboratory, New Delhi, is being manufactured on a large scale. It consists of a concave metallic plate which focuses the sun's rays on an iron ring. Photo, left, shows it being used in conjunction with a pressure cooker with which it can cook vegetables in ten to fifteen minutes. Sun's heat from reflecting surface will bring water to boiling point in 20 to 30 minutes. Thanks to solar cookers sparse vegetation and animal dung—at present used in many countries as fuel—will be saved for the protection and improvement of the land.

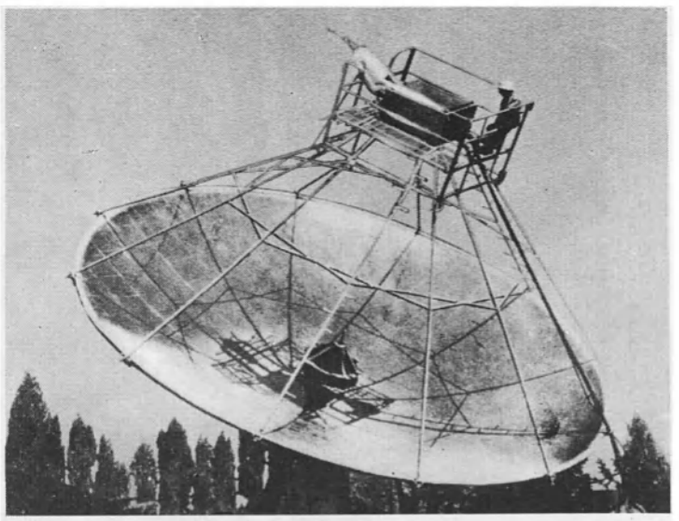
Winslow, American University, Beirut.

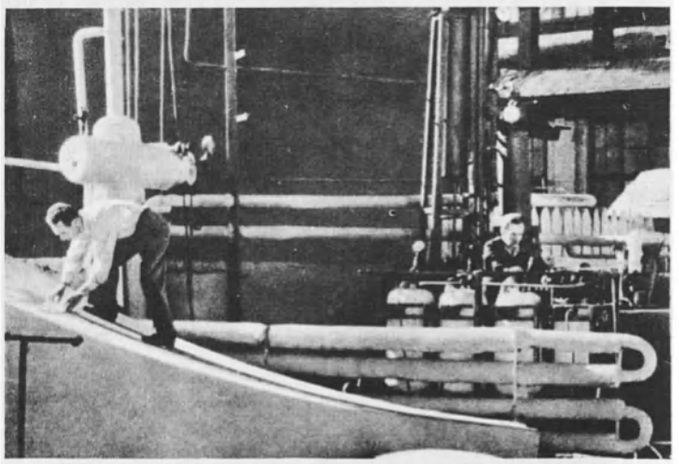




STEAM FROM GIANT RUSSIAN MIRRORS

The Soviet Union with almost one million square miles of arid land has devoted years of research to developing practical means of putting the sun's energy to work. Recently the U.S.S.R. made the startling announcement that it had developed an apparatus capable of producing steam by solar energy. Photo above right, shows one of these reflectors, a giant curved mirror over 30 feet in diameter whose heat energy can produce steam. These heaters can operate canneries and refrigeration plants as well as distil fresh water from sea water. Recently a solar engine was developed for industry which produces 33,000 tons of steam per year. Russian technicians have found that distillation plants powered by solar energy provide the cheapest method of purifying water for livestock grazing in remote desert pastures. Photo below right shows interior of solar energy plant. Photo adjoining page shows metal being soldered by solar energy at Tashkent Experimental Laboratory. (Official Soviet photos)





THE DESERT'S GREATEST RESOURCE

(Continued)

repairs." A useful engine should cost no more than a horse, bullock or camel and should have a work-life at least as long as the animal's. It would free for human nutrition the land now used to feed the animal. In India it would save for much-needed fertilizer the cow-dung now used for domestic fuel. In desert areas it would reduce the cutting of shrubs for fuel, thus preventing the spread of desert conditions.

Even cloudy weather does not necessarily destroy the effectiveness of solar engines, according to Dr. A. E. H. Bleksley of the University of Witwatersrand (South Africa). He reported at New Delhi on measurements made during the past forty years of the amount of solar radiation at different locations and in different climates. He told the symposium, "Except in the relatively rare cases of a sky completely covered with a dark cloud layer, the presence of diffuse radiation serves largely to compensate for the loss of direct radiation due to thin or scattered clouds or to considerable quantities of dust in the atmosphere".

While there is ample energy in sunlight, the chief difficulty in making use of it is that it is spread so thinly. Nowhere on earth is the direct heat of the sun sufficiently intense to boil water. The highest temperature on record is 136.4° F. (At Aziziya, Libya, in 1922) but water boils at 212° F. For this reason sunshine from a larger area must be gathered and concentrated into a small area to attain the necessary temperature, as small boys focus sunshine with a lens that they call a "burning glass". This is effective but involves the mechanical difficulty of moving the mirrors about with the change in the position of the sun during the day.

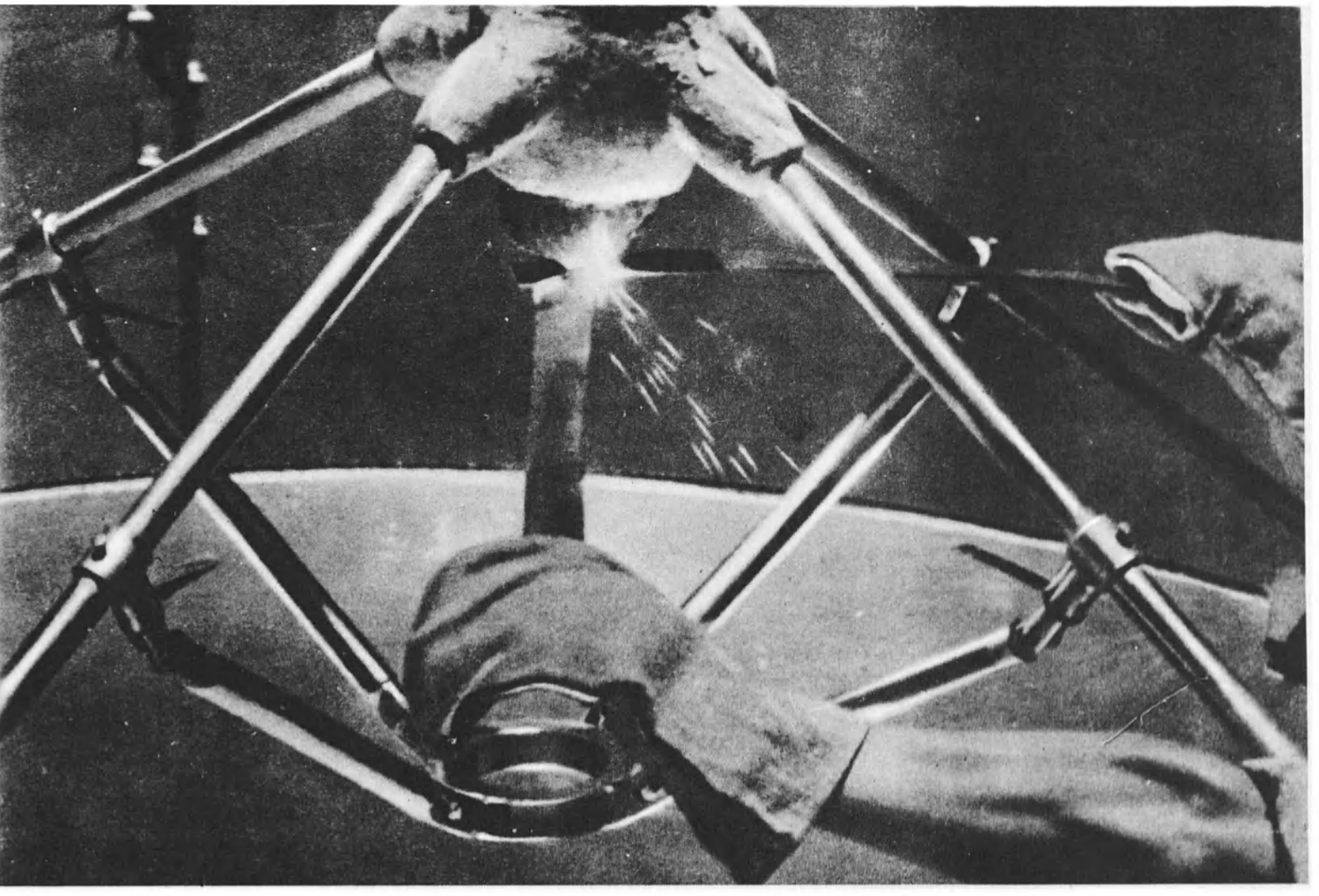
Nevertheless by such means a simple device was developed for home use by the National Physical Laboratory at New Delhi in India. It consists of a metallic plate curved into a concave shape and supported on a stand so that the sun's rays are reflected upward from the polished metallic surface and are thus concentrated on an iron ring at the focus, or centre of curvature. When a pot of water or of rice is set on the ring it absorbs the sun's heat from about one square yard of surface and is heated to the boiling point in 20 to 30 minutes. This solar cooker is to be manufactured on a large scale and should be effective in avoiding the use of scarce fuel, particularly in the many arid regions. It serves well for cooking and is of value in saving both sparse vegetation, and fertilizer for protection and improvement of the land instead of using them a fuel.

But to obtain sufficient energy to operate a pump, long cylindrical mirrors are more useful. At the focus of such mirrors a glass tube filled with water serves as a boiler. By various modifications of mirror systems it has been possible to generate three or four kilowatts of the energy as steam which can be harnessed to an electric generator, there turned into electricity to operate a motor and thus a pump.

Sun makes 12,000 tons of ice a year

At the same symposium, there was a striking report by Professor V. A. Baum, head of the Heliotechnical Laboratory at the G. M. Krzhizhanovsky Power Institute at Tashkent in the Soviet Union. He said that Soviet scientists have succeeded in developing curved-mirror (paraboloid) reflectors ten meters in diameter which produce 100 pounds of steam per hour at a pressure of 100 pounds per square inch. Such heaters have been used for the operation of canneries, for distilling water, operating refrigerators, and for heating the laboratory.

Similar heaters have also been developed to make fresh water from salt water. A practical still of this type produces 250 gallons of distilled water per day and uses only 4 pounds of steam per gallon. This proves to be the cheapest method of providing water for livestock grazing in the Kara Kur desert. A still of this type has been used to make 75,000 tons of distilled water and 12,000 tons of ice a year.



One of the great handicaps of solar energy is its discontinuous operation. There is no way to make sun shine during the night, nor on days of dense clouds. The pumping of water for irrigation is not seriously handicapped but the generation of electricity for home and village lighting in the evening, which is an important function of a possible solar engine, obviously requires the storage of power.

In a discussion submitted to the United Nations Conference on the Peaceful Uses of Atomic Energy, Dr. Farrington Daniels made the following suggestions on the storage problem : One obvious solution is to pump water to a reservoir at a higher level and allow it to fall back at night to operate a water turbine and dynamo. For many years a mine in New Mexico (U.S.A.) was lighted day and night by electric lights operated by a dynamo and solar engine. A parabolic mirror focussed sunlight onto a boiler which ran a steam engine and pumped water into a 5,000 gallon tank 20 feet above the ground. One can imagine that if solar power should become important those communities would be favored, which have a high plateau nearby for easy construction of a water reservoir to store hydro-electric power. Abandoned mines with a water turbine at the bottom might be used also, the water being pumped up during the day and allowed to flow back during the night. Diving bells with deep chambers in the ocean to be pumped out during the day, might be used by coastal cities.

Electrical storage batteries would also serve the purpose and in principle they are ideal. The lead storage battery has been developed for automobiles to a high state of perfection. It is too expensive and requires too much attention for general use in non-industrialized areas. But for use with solar engines, says Dr. Daniels, the storage battery need not be strong, rugged and of small size. It does not have to give a high amperage and it does not have to be instantly and completely reversible. Ignoring these requirements of our present lead storage batteries, it may well be that new chemical systems and new types of electrodes can be developed. For general use, the cost should be no more than one-tenth that of present lead storage batteries.

There are thus a number of approaches to the problem of power in the desert. They are important because small local sources of power would not only be useful in cooking and in lighting remote communities but would also permit the use of arable land to grow human food in place of the vegetation that is now required to feed the animals that are the present sources of power. This alone would accomplish a considerable increase in the food production in arid lands. Where underground water is available such local power resources would of course be primarily valuable in permitting irrigation and thereby further increasing food production.

House warming by 'heat traps'

There are however, other uses to which the sun can be put, namely, the heating of houses and of water for domestic use. In many desert countries the temperature is very hot by day and yet uncomfortably cold at night. In such locations house heating requires the absorption of the sun's energy by day and its storage for use by night. Since this use does not require the generation of steam or a high temperature the collection of sunshine is a much easier matter. It is done quite simply by using a "heat trap", an insulated box exposed to the sunshine on the roof. It is blackened on the inside to absorb heat and is covered with a piece of glass or a thin sheet of transparent plastic. The cover allows visible sunlight to pass into the box where the short visible light waves are transformed into the much longer waves of heat radiation. This does not pass through the glass or plastic and the box becomes quite hot. The hot air from this box is then led to a storage bin which is filled with crushed rock or gravel. This is heated by the air and retains the heat. By night, cool air passes through the storage bin and, warmed by absorbing the heat from the rocks or gravel, in turn warms the house.

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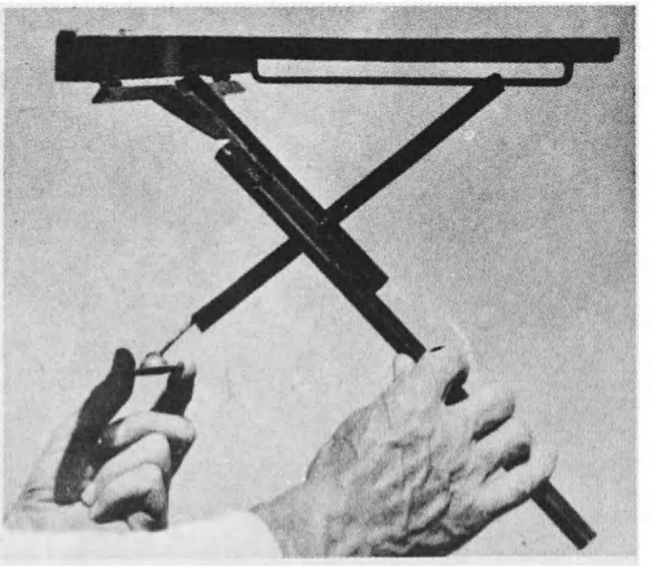


MULTI-MIRROR solar heater is one of many devices being developed at India's National Physical Laboratory. Battery of cheap, flat glass mirrors (left) concentrates sun's heat. Each mirror is fixed on its own small mounting (right). All mirrors can be tilted as a group by a single automatic control to reflect rays into single focus. Heater is designed to provide power for small steam engines or electric motors. (PIB-Government of India photos)

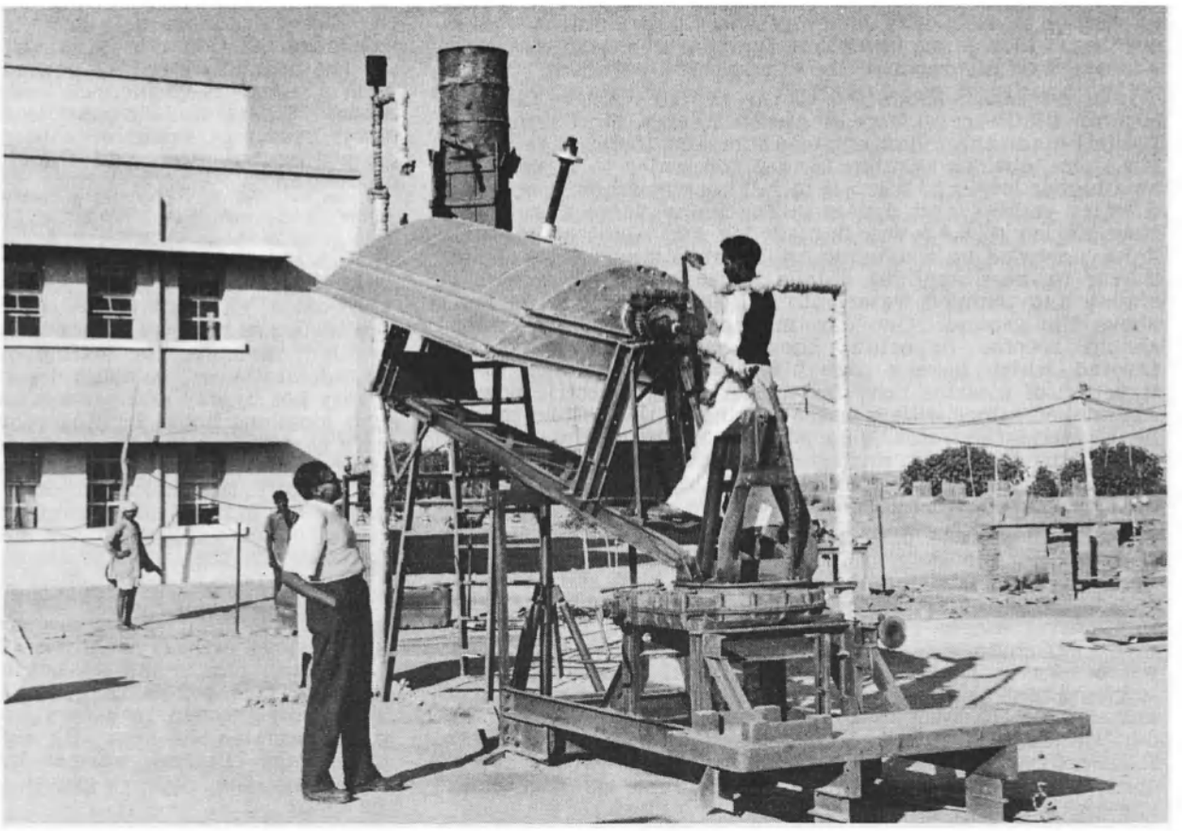
Water heating for domestic uses, including the washing of clothes, is done similarly, the water in a storage tank being gradually heated by the hot air from the heat trap on the roof. For example in the Russian village of Firusa near Asshabad, a solar heat collector with a surface of 900 square feet provided 10.5 tons of hot water in 24 hours at a medium temperature of 120° F.

One other possibility is available for future use. In April 1954 the Bell Telephone Laboratory announced a solar battery able to transform sunlight directly into electrical energy without the use of heat. It employs two thin wafers of very pure silicon in contact with each other. This highly purified silicon now costs $380 per pound. Although the wafers are thin the cost of such a battery is very high and it is used as yet only to produce electrical power for amplifier stations on rural telephone lines. Yet it is remarkably effective. The current is about 25 milliamperes per square centimetre or 2.5 amperes per square metre at a voltage of 0.3 volts. This indicates a high efficiency in the utilization of sunshine, up to 8 % being common and it has reached eleven per cent.

The promise of this direct method of generating electricity from the sun therefore depends only on the possibility of manufacturing silicon, which in its common form is a cheap metal, in high purity at a low price.

It is apparent from this survey that utilization of sunshine for heat and for power has been neglected in the past, partly because the researches have been done in highly industrialized countries where ample coal is available, and where sunshine can hardly compete. Present attention to the needs of arid lands where coal and other fuels are either costly or lacking, has revealed many promising possibilities and it is now legitimate to anticipate that practical means of using the sun will gradually become available to desert peoples and that sunshine will become a valuable resource that can be converted into food, fuel and power to improve the standard of living.

Dr. GERALD WENDT, American science writer and author, was former head of the Division of Teaching and Dissemination in Unesco's Department of Natural Sciences. Formerly professor of chemistry at the University of Chicago and Dean at the Pennsylvania State College, he has devoted many years to interpreting science and its social consequences to the public. At the recent Geneva Conference on the Peaceful Uses of Atomic Energy, Dr. Wendt was science consultant for the U.N. Radio.



KEEPING COOL with the help of solar energy is now a scientific possibility with this sun-powered steam-producing apparatus being tested at the National Physical Laboratory, New Delhi, India. Machines which make use of solar energy to work air-conditioning or refrigeration plants, to cook food and to provide cheap industrial power are being developed at this centre. (PIB-Government of India photo)

Solar 'Factory'

A JULES VERNE SETTING IN THE PYRENEES

by Daniel Behrman

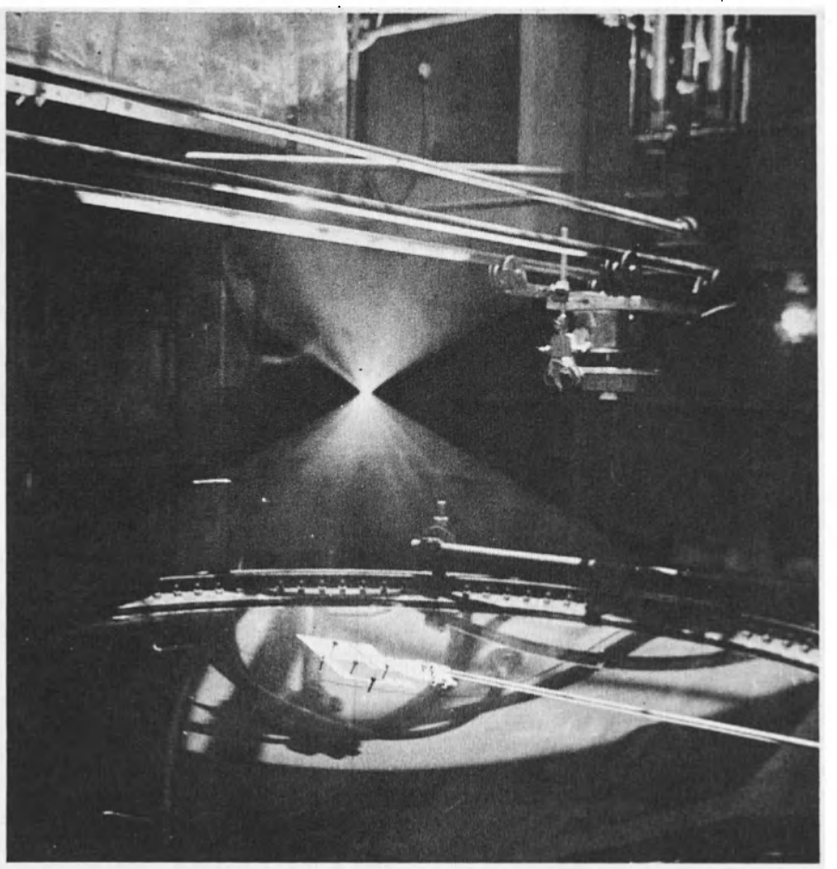
BEHIND the moats of a grim 17th Century fortress in Southern France, a team of French scientists has succeeded in turning the age-old dream of harnessing the sun into an everyday economic reality.

At Mont-Louis, 5,250 feet high in the eastern Pyrenees near the Spanish border, zirconia, which is used in lining furnaces, and other refractory materials are being produced by solar energy at a cost 25 per cent lower than that of conventional electric arc methods.

The "factory" consists of two giant mirrors which step up the sun's energy striking the earth by no less than 20,000 times to create a temperature of 3,000 degrees Centigrade (iron melts at 1,539 degrees Centigrade) at the mouth of a solar furnace about the size of a small wine barrel.

This glimpse of the future is the achievement of Professor Felix Trombe, director of the Solar Energy Laboratory at Mont-Louis, and Marc Foex, its assistant director. It is the result of more than twenty years of research in high-temperature treatment of metals and nine years of experiments with solar energy.

Recently, the UNESCO COURIER sent this correspondent to Mont-Louis. He expected to find a Jules Verne setting—and he was not disappointed.



FOCAL POINT of solar furnace at the Mont-Louis Solar Energy Laboratory, France. Concentrated heat from sun rays in the centre of photo (they produce a temperature of 5,500 degrees F.) was made visible by throwing a handful of powdered aluminium at focal point of rays. Furnace is used for high temperature treatment of metals.

The fortress at Mont-Louis was built by the Marquis of Vauban, Louis XIV's great military engineer in 1676, and it has changed very little since then. You enter the solar energy laboratory over a bridge crossing a moat. The great wooden gates with their nail-studded flanks guarding the bridge have not changed in 300 years either.

The COURIER'S correspondent asked a tall man in his late forties, wearing rope-soled espadrilles and perched on top of a framework of girders, where Monsieur le Professeur Trombe could be found.

"I'll be right down," said the man on the girders, "You'll have to excuse me—we're making our plans as we go along."

Prof. Trombe led the way into his office and sat down at a desk covered by great white vases which he used indiscriminately as ashtrays. I pointed to one. "Melted quartz from the solar furnace", he explained, throwing a match into it.

In his office, Prof. Trombe and his assistant director explained how they turned to solar energy in 1946 as a way of producing high temperatures for treating minerals. "With solar energy," said Prof. Trombe, "you can keep substances free from carbon or other impurities, for energy can be produced independently of any chemical reaction." This also enables the metallurgist to control the properties of the atmosphere inside his furnace to a high degree of precision.

They started on a modest scale at the Meudon Observatory near Paris. The weather in the Ile-de-France was not exactly ideal for their experiments, and they had only reflectors from wartime anti-aircraft searchlights for use as parabolic mirrors. Still, they could see they were on the right track.

In 1949, General Paul Bergeron, director of the French National Defence Scientific Activities Committee, saw their experiments and agreed with them. He offered them a new site, Mont-Louis in the sunny Cerdagne country of the Pyrenees.

There are now 20 research workers at Mont-Louis and 25 more in Prof. Trombe's laboratory in Paris. The work is financed jointly by the French National Defence and especially by the French National Centre of Scientific Research and the Ministry of Education.

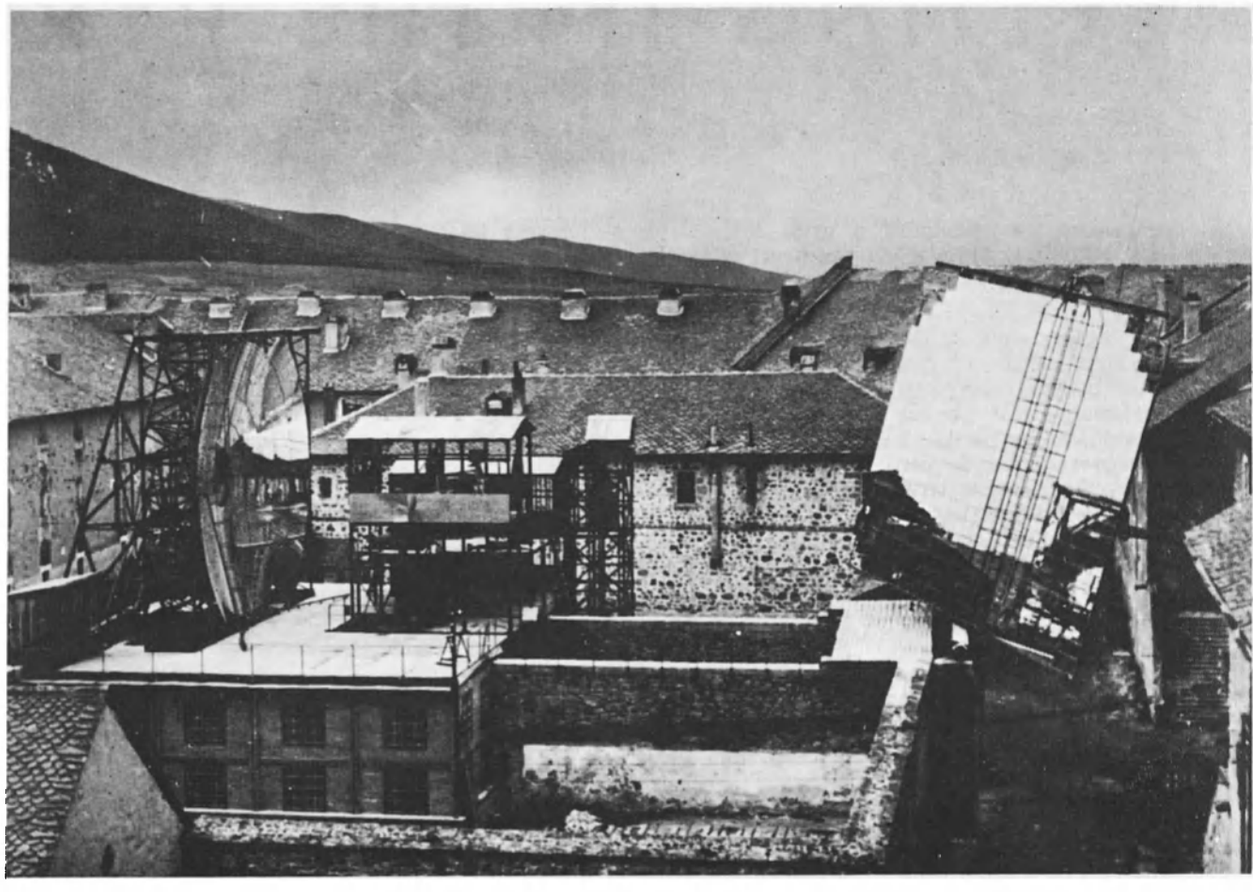
"We build our own apparatus", said Prof. Trombe. "Our team believes in what we are doing."

The new site in the Cerdagne offered Prof. Trombe and Mr. Foex the sunniest region in France, a "micro-climate" only 300 square miles in area and protected by mountains against the *carcanet* wind from the north and the damp southwesterly gusts from the Atlantic.

At Mont-Louis, the solar energy laboratory can count on 200 sunny days a year—at Meudon, it had 50. For solar energy purposes, Prof. Trombe explained, the regions near the Tropics of Cancer and Capricorn are ideal. Closer to the Equator, there is too much moisture in the atmosphere.

The first major problem to be overcome in 1949 was one of cost. To make a parabolic mirror only six feet in diameter requires a lense costing 1,500,000 francs ($4,200 or £1,500)... and the (Cont'd on next page)

LOW BUDGET MUCH INGENUITY

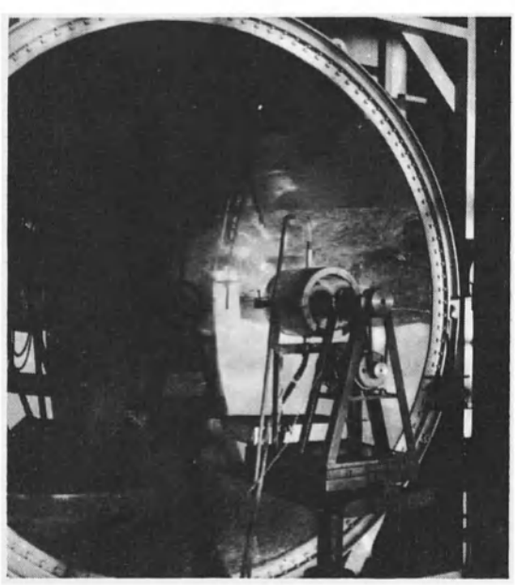


FORTRESS WALLS built by Vauban, Louis XIV's great military engineer, provide 17th century setting for a spectacular modern research device. In the old fort at Mont-Louis, in the Pyrenees, flat mirror (right) follows passage of sun across the sky and reflects rays to parabolic mirror (left), so curved that it concentrates all rays into the orifice of the solar furnace (centre).

parabolic mirror now used at Mont-Louis is more than 30 feet in diameter!

Prof. Trombe and Mr. Foex solved the problem with a low budget and a great deal of ingenuity. Their parabolic mirror is the largest in the world, but it consists of nothing more than 3,500 lozenge-shaped pieces of window glass. Each piece of window glass is only 1/16" thick and is laterally warped into the shape of the great parabolic lens by the pressure of adjustable screws.

In operation, the solar furnace is a weird sight. A flat mirror 426 square feet in area rises up next to one wall of the fortress with a great piston behind it to control its movements. This mirror, consisting in turn of 520 individual mirrors, has the job of catching the sun at any angle and sending its rays into the fixed parabolic mirror 80 feet away which then focuses the rays into the orifice of the solar furnace placed between the two mirrors, an orifice about as big as the porthole of a small boat. All of this is done automatically. One pane on the flat mirror sends the image of the sun between photo-electric cells. As the sun moves, so does the image, and photo-electric cells respond, sending an order down to the pistons which move the flat mirror.



WAR SURPLUS REFLECTOR from anti-aircraft searchlight was enlisted by Prof. Trombe to serve as a parabolic mirror in his early tests and still does duty at Mont-Louis for small-scale experiments. Cylindrical solar furnace shown here is rotated by an electric motor.

One of the laboratory's engineers started the machinery to demonstrate how the flat mirror could be moved. It looked like a great blind animal turning slowly as it worshipped the sun. Up on the platform between the two mirrors, Prof. Trombe led me quickly into the tiny shed housing the furnace. The day was overcast, but I could still feel a breath of heat from the mirror. "You have to be careful here," he said, "that mirror once burned the overcoat of a very important visitor."

The furnace stood in the axis of the parabolic mirror. At a touch of a switch, it began to spin rapidly. In operation, explained Prof. Trombe, centrifugal force pushes the mineral under treatment against the cylindrical wall of the furnace and forms the "vases" which I had seen on his desk.

First, a refractory material such as zirconia is produced in the furnace to form a crucible which can then be used for making metals, again of pure quality.

The present solar energy plant at Mont-Louis has a power rating of 75 kilowatts (the equivalent electric furnace would require a dynamo with a 100 h.p. motor). Prof. Trombe told the UNESCO COURIER that plans are now well advanced for a 1,000-kilowatt solar energy plant (the equivalent of a 1,300 h.p. generator).

A site has not yet been chosen definitely for this new plant, but it will consist of a parabolic mirror measuring

115 ft. by 165 ft. with an area of 1,793 square yards. With this new mirror, Prof. Trombe hopes to drive down the cost of producing refractory materials to one-half that of the electric furnace. Even with the present mirror, the plant at Mont-Louis would pay for itself within five years if it did nothing but produce refractory materials.

"Of course, we don't," said Prof. Trombe, "We are a research laboratory, not a factory. Still, running the furnace commercially only 30 days a year, we produce two tons of refractory material and, since it's extremely pure, we have no trouble finding buyers for it."

What of the future? "Solar energy will develop according to the world's needs and the problems raised by existing methods of producing energy," said Prof. Trombe.

At Mont-Louis, as elsewhere, experiments are also being conducted in the heating of buildings by the sun and, not at all paradoxically, in refrigeration (the use of solar energy in the refrigeration cycle to replace electricity or a gas flame as a source of energy has been demonstrated over and over again and a house in the Sahara air-conditioned by the sun is not by any means as fantastic as it sounds).

Prof. Trombe firmly believes that in producing high temperatures for certain metallurgical work, solar energy is now the most economical source available. The great stumbling block lies in converting it into motive power.

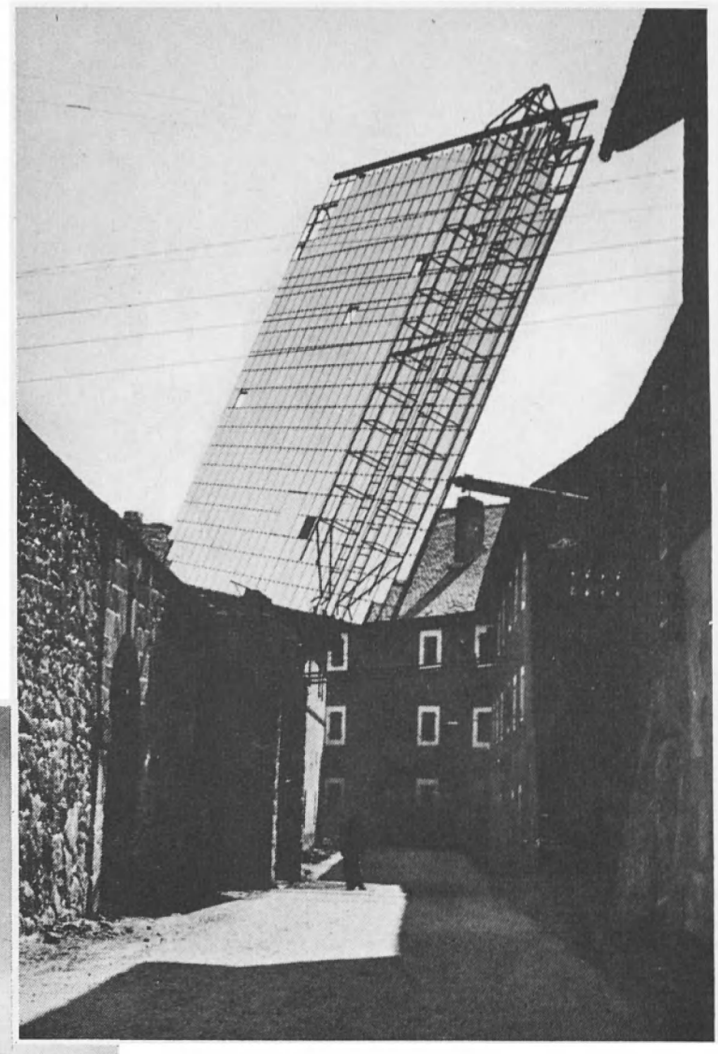
"As soon as we try to use the sun to heat a boiler, we are up against the fact that the steam engine is the most inefficient of all power plants", he said, "It only converts into energy about five per cent of the calories you put into it. Under such conditions, it cannot compete with the Diesel engine as a small power plant for isolated regions."

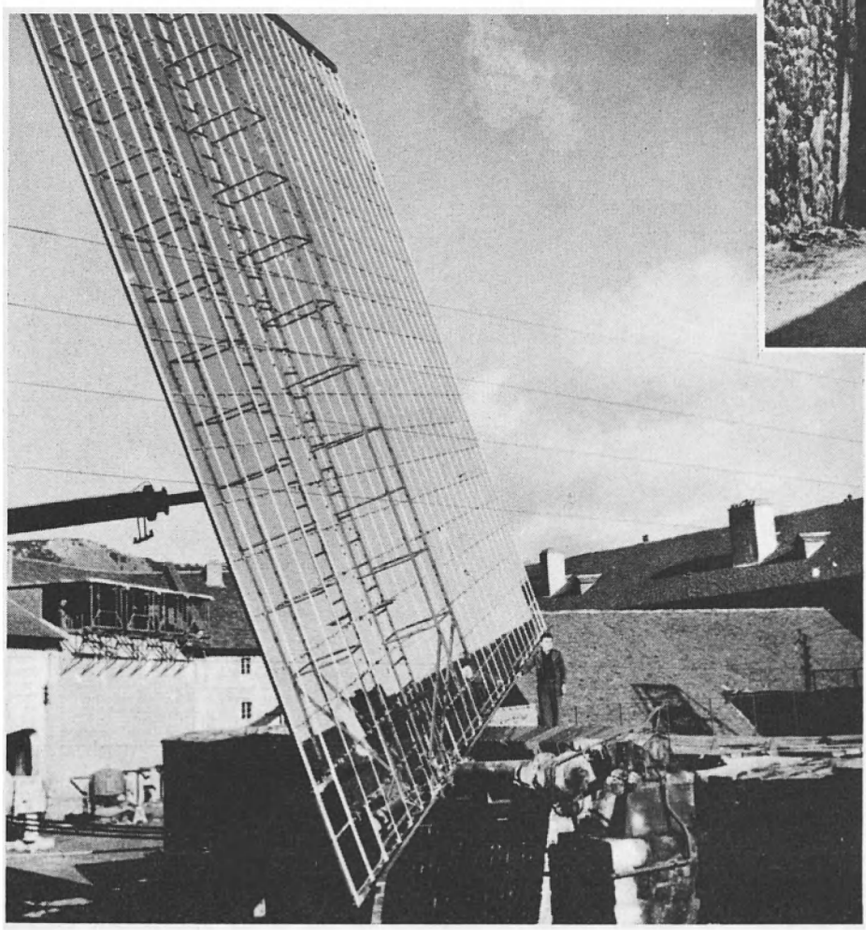
Prof. Trombe told the COURIER, however, that he does see a possibility of using the sun to drive efficient turbine power plants of at least 100 h.p. to generate electricity.

"I do not think there is any problem in producing power after sundown", he declared. "Heat can be stored by certain materials and, at midnight, we have measured a temperature of 1,000 degrees Centigrade in our own small furnace. There is no reason why a solar plant could not supply power during the peak hours of the evening—although you would need an auxiliary engine, of course, for days when the sun doesn't shine at all. The economics of solar energy depend on the availability of other sources of energy."

As I left Mont-Louis, Prof. Trombe and Mr. Foex showed me another source which has been definitely supplanted. Less than 20 yards from the high-temperature furnace and the world's largest parabolic mirror, a door led into a dank hall where a wooden wheel 15 feet high rose up in the darkness.

"This is the 'Convicts Well'," said Prof. Trombe, "It worked in the same way as a squirrel cage only with a man inside to draw up water from a secret well."





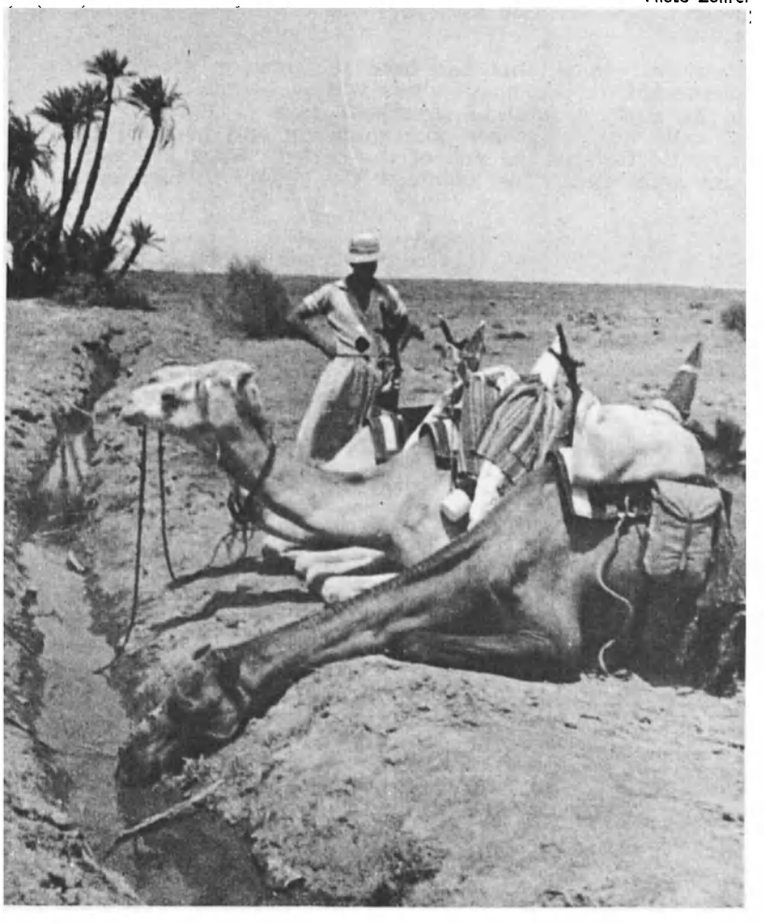
SUN CATCHER, a mirror 40 feet across and composed of 520 individual mirrors, rises up next to one wall of the fortress. It is mounted on a pivot so that it can do its job of catching the sun at any angle. Sun's rays, acting on photo-electric cells, send " orders " to the great piston which controls mirror's movement. (All photos these pages courtesy Solar Energy Laboratory, Mont-Louis)

TAKE A DEEP BREATH ! The camel's unique ability to go without drinking water is the result of half a dozen extraordinary gifts that are not shared by any other animal. While he cannot store water as such, he conserves every drop of water in his body tissues. The camel never pants, never breathes with mouth open even in the hottest Saharan weather and perspires so little, because it can regulate its body temperature, that its skin always feels completely dry. Here Prof. Schmidt-Nielsen uses a special apparatus to measure oxygen consumption on one of his experimental subjects.

Copyright Schmidt-Nielsen

THIRSTY CAMELS are the exception rather than the rule. After being deprived of drinking water for two months, two camels at the Beni Abbès research centre showed no interest in water when it was offered. They had obtained enough from the winter desert vegetation. In summer a camel was kept without water for eight days during which time it lost 100 kilograms in weight. When given water it drank 103 liters in ten minutes, thus restoring the lost 100 kilograms. Experiments showed that camels only drink enough to restore normal water content of their bodies.

Photo Zohrer



THE CAMEL

Facts and Fables

by Bodil and Knut Schmidt-Nielsen

Up until a few months ago, the camel was one of the great riddles of nature. No one knew how the "ship of the desert" could survive hard work in the blazing heat and go for so long without a drop of water. It was once believed that the camel stored water in its hump and more commonly that it drank huge quantities of water which it stored in one of its several stomachs. The mystery of the camel has now been solved as the result of a painstaking investigation carried out in the North Sahara under the auspices of the Unesco Advisory Committee on Arid Zone Research. Working in a region where the temperature often reached 140 degrees Fahrenheit, a research team led by Prof. Knut Schmidt-Nielsen of Duke University, U.S.A., put the camel through its paces and came up with some startling findings. In the article published below, specially written for the Unesco Courier and copyrighted, Professor Schmidt-Nielsen and his wife describe their experiments and the results they achieved.

★

THE exceptional abilities of a camel as well as his unusual appearance have for centuries attracted the attention of travellers, naturalists, and zoologists. Legends and fables have been intermingled with factual information, amazing stories have been told, and it has been difficult to know whether such accounts represented truth or tale.

The camel is of great value in many desert areas where it is often the most important domestic animal. Not only is it the principal beast of burden, but it gives milk and its wool is used for clothing and tents. In spite of the advancements in technological culture it is likely that the camel will keep its present role in the desert economy for long periods to come. Some factual information on this remarkable animal is much needed.

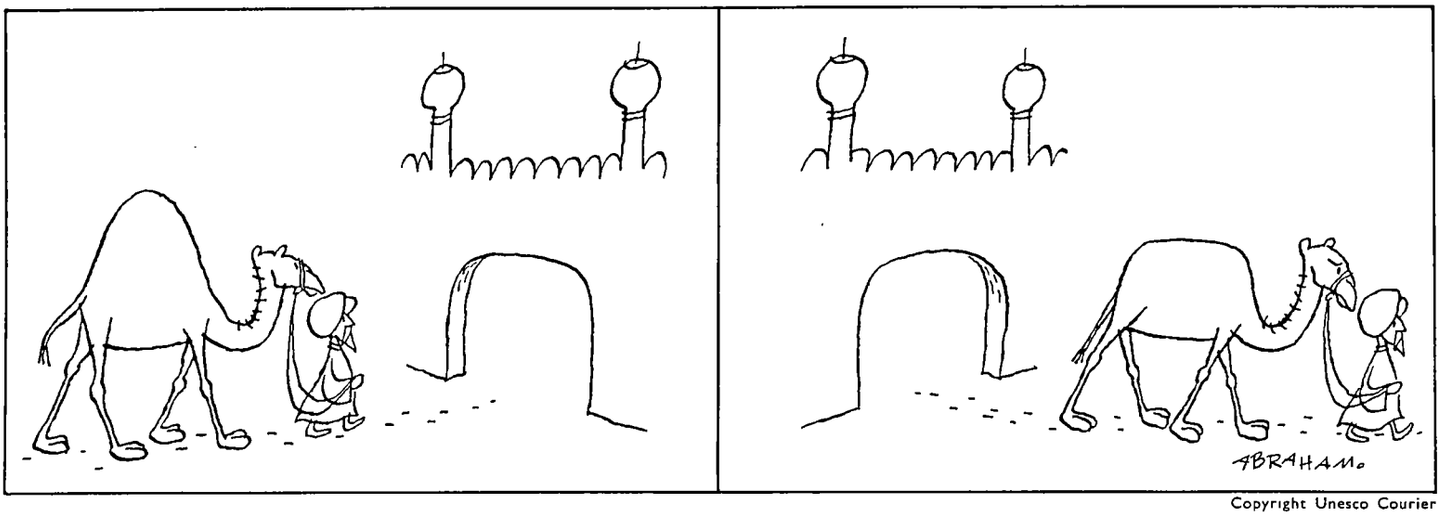
Legend has it that the camel can cross the most scorching desert without water or food. There is no doubt that the camel has very unusual abilities in this direction, and the popular appeal of tales of desert adventure has created a great deal of interest in the endurance of this animal.

It is remarkable to learn how little scientific information is available about an animal on which people depend for their livelihood over vast geographical areas. Until recently, many common questions could not be answered by science, such as: How long can a camel go without water? How is it that the camel can get along without water under such difficult conditions? Does the camel have a store of water in its body? What is the function of the camel's hump? etc.

A better understanding of the camel and its functions would be of importance in evaluating the future of arid lands and programmes for agricultural improvements. Knowing more about the characteristics that enable the camel to get along in the desert will perhaps also contribute to the evaluation of characteristics that make other animals, such as sheep and cattle, tolerant to an arid climate. It was therefore natural that UNESCO, among other institutions, supported an expedition on which scientists from Duke University attempted to find answers to many of the unsolved problems about the camel. The group consisted of scientists, the two authors of this article and our excellent collaborators, Dr. T.R. Houpt from the University of Pennsylvania, and the Danish physician Dr. S.A. Jarnum. Our field studies were carried out in the

(Cont'd on next page)

KNUT and BODIL SCHMIDT-NIELSEN are a husband and wife team of zoologists who collaborate in investigating the physiology of desert mammals. Knut Schmidt-Nielsen, a Norwegian, studied in Copenhagen under August Krogh, Nobel laureate in physiology and medicine, and married his mentor's daughter. Husband and wife came to the United States in 1946 and are now at Duke University. In 1954, under a Unesco grant, they worked at Béni Abbès research station, Algeria, making intensive heat studies on the heat tolerance and water storing capacities of the camel.



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Algerian Sahara in 1953-54, with headquarters at the French research station, Centre de Recherches Sahariennes. Our work was greatly facilitated by the support and help we received from the Director of the Centre, Dr. Menchikoff, and from local French authorities, represented by Capitaine Lepage at Béni Abbès.

How long can a camel go without water ?

If one asked the question : "How long can a man live without water?" the answer would depend on the circumstances. In the desert in the summer, it might be one or two days. But it might be a longer time, perhaps a week, in a cool climate. Furthermore, if the man had some succulent food such as melons he could manage for a longer time. In fact, he might do perfectly well without any drinking water if he had an adequate supply of juicy fruits such as apples, oranges, tomatoes and melons.

The same thing goes for the camel; how long it can live without drinking depends on external conditions. The answer will depend on factors such as the amount of food and its water content, how much load the camel carries, how far it has to travel, the temperature, and also the breed of the camel, and its condition. It is therefore impossible to say that any camel can endure abstinence from water for a certain number of days.

There are two kinds of camel, one-humped and two-humped. Those we worked with at Béni Abbès were one-humped camels or dromedaries. The two-humped, or bactrian camel belongs to the desert and high plateaus of central Asia. while the one-humped camel is found in the hot deserts of Arabia and North Africa.

Observing camels in the Sahara Desert, we soon found that those that were grazing in the winter were usually not watered at all. This is not surprising because if it rains the vegetation in the desert contains a considerable amount of water. We examined a number of such camels that were brought to Béni Abbès to be butchered. They had been without drinking water for one or two months, and one might think that these camels would be very thirsty, but this was not the case. If they were offered water they showed no interest in it whatsoever. However, the winter rains are very irregular, and in dry winters when the usual growth of new vegetation is absent the camels would undoubtedly have to be watered.

To find out how much water a camel needs we would have to give them some dry food instead of the ordinary pasture. We therefore fed them dry hay and dry dates. The dates that are given to camels differ from the sweet, soft dates eaten by humans, and are dry, hard and not as sweet. We kept a camel on this dry feed for several prolonged periods, the longest being sixteen days in January. After this, the camel was rather thirsty but in no way in serious condition. The conclusion was that the camel can easily be without drinking water for more than two weeks in the winter, even when the feed is dry.

The camel continues to use water during such periods of water deprivation. Like all mammals, it must use water for the formation of urine, and water evaporates from the lungs when it breathes. In the camel the continued loss was indicated by a decrease of body weight corresponding to the amount of water used. It continued to eat, and had water been available it would have maintained its usual body weight. At the end of the sixteen-day period it drank an amount corresponding to the expenditure, bringing the body weight back to normal.

This experiment did not tell us how much depletion of the body water the camel can withstand. We could have continued the experiment to find out, but there were other pressing problems and we decided to wait until the summer. Then the rate of water loss would be much higher, and the camel would become seriously dehydrated in a much shorter time.

In late June we kept a camel without water for eight days, and it had then lost 100 kg in weight, the original weight being 450 kg. It was at this time in a rather serious condition from lack of water, and when allowed to drink consumed 103 litres of water in ten minutes. This experiment shows that camels can tolerate losing about a quarter of their body weight in water, and that they can drink it back in a few minutes.

Another camel that had been subjected to more experimentation on this ocasion was without water from June 5 to June 22, a total of seventeen days. Both of these animals were in rather poor condition and had lost their appetite towards the end of the period. They looked thin and emaciated. The abdomen was drawn in against the

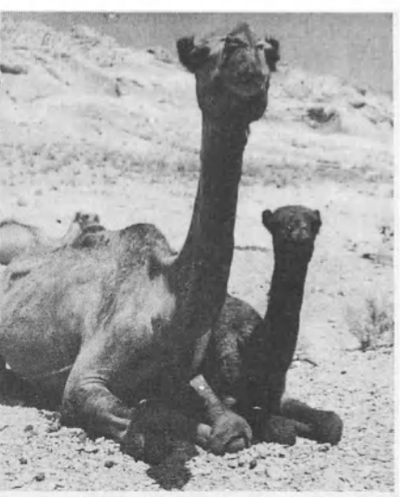
vertebral column, the muscles were shrunken, the legs were scrawny and appeared even longer than usual. They would not have been fit for heavy work or long distance travel in this condition.

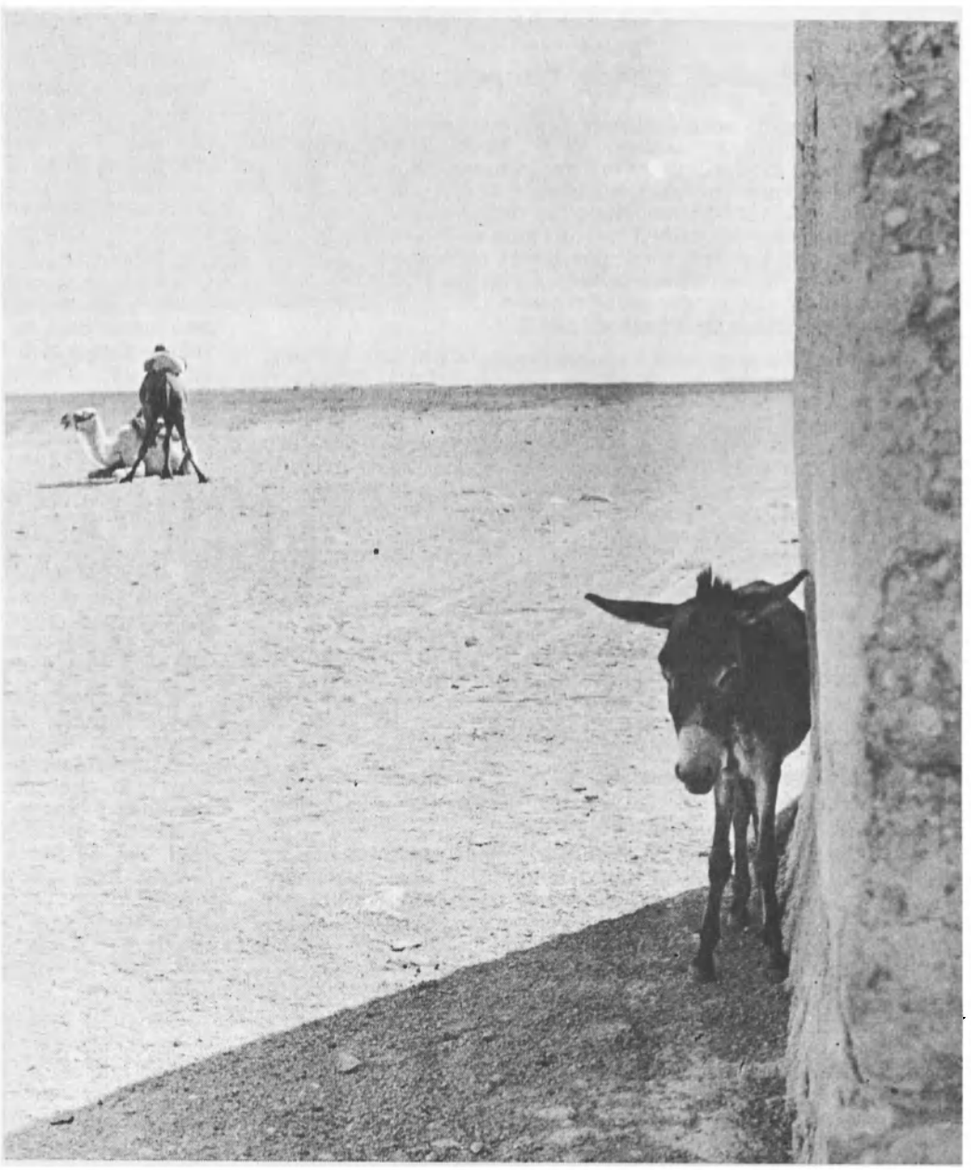
These two camels had been exposed to the hot desert wind and sun but they had not been worked. Judging from this experiment it seems likely that even the best camels could not be used for desert travel without water for much beyond a week in the summer. However, this depends on so many factors that extensive investigation under various conditions would be necessary before definite rules could be given.

Still, it can be stated that the length of time the camel can live without water far exceeds that of other mammals, including man. Under similar conditions it is likely that man would be seriously debilitated and in very poor condition after one day's travel in the desert and would probably die of thirst during the second day.

Does it really store water?

MANY travellers have suggested that the tolerance of the camel to lack of water is explained by a storage of water in the stomach or other parts of the body. In support of this view one will often find related the well-known tale of the Arab who is out of water in the desert and will kill his camel as a last resort and drink the water he finds in its stomach.





It is easy to understand how the idea of water storage could arise. Before a long journey in the desert one would of course water the camels. If they had been without water for a few days previously they would consume large quantities of water, and to the uncritical observer this might look as if the camels were taking in huge quantities of water in anticipation of the coming needs. However, as mentioned above, we observed that camels would drink a quantity of water corresponding to that which had been lost in the period of water deprivation, but they would drink no more water than needed to make up for that lost. We observed no instance in which a camel drank an excess of water that could be regarded as storage.

The belief that the camel stores water is widespread, and has been supported by the fact that the structure of the stomach is rather unusual. The camel is a ruminant, and like the cow and sheep it has a stomach that is divided into several parts or compartments. The first and largest part is the rumen, which contains the coarsely masticated fodder.

This rumen has certain sacs in its walls which are not found in other ruminants, an interesting fact which has been linked with the legend of water storage. However, the volume of these little pouches which have been called "water sacs" is so small (5 to 7 litres) that they could not possibly store water in the quantities necessary to meet the needs of such a large animal.

The rumen of camels does contain large quantities of fluid, but this is characteristic of all ruminants. However, to make sure that water was not stored we analyzed the fluid from the stomachs of a dozen animals. First of all, the fluid is a rather foul smelling, unappetizing, green fluid with little similarity to drinking water.

Chemical analysis reveals that it has great similarity to digestive fluids, and its salt content is closer to that of blood rather than to water. Furthermore, the so-called "water sacs" usually contained masticated food and not much fluid. We thus found no scientific support of the fable of water storage.

Although fluid that is found in the camel's stomach is rather unappetizing it could very well be used for drinking in an emergency. The tale of the Arab who saves his life by killing his camel in order to drink the water in its stomach may be true, and the mistake is made in the implication that the fluid found is stored water.

A grain of truth in the hump story

SOME people have stated that the camel's hump contains the camel's water reservoir. However, the camel's hump is practically exclusively fat and is an energy storage just as the fat of other animals. It is a curious fact that the fat of several animals that live in hot climates is found in one location rather than distributed over the body. The Indian or Zebu cattle have a hump over the shoulders, and the fattailed sheep carries the fat in a tremendously enlarged tail. To the Arabs the camel's hump is a prized delicacy, and when camels are butchered the hump often gets a higher price than the meat. Although it is quite clear that the hump does not contain water, there is a grain of truth in the belief that the camel gets water from the hump. Whenever organic material is burned, water is formed in the process. Most people will have noticed that if a pot of cold water is placed over a fire, water condenses on the outside of the pot. This is *(Cont'd on next page)*

IT LOSES (100 KILOS. IN 8 DAYS), DRINKS (100 LITRES IN 10 MINUTES)

water which is formed by oxidation of hydrogen present in the fuel. In the same way, water is formed when fat is oxidized in the animal's body. However oxygen is required for the oxidation, and the air that is pulled into the lungs is exhaled again, saturated with water vapour.

The amount of water lost this way depends upon temperature and humidity, but usually water is lost by evaporation from the lungs of the camel about as rapidly as it is formed. Therefore, the fat of the hump does not mean a large extra storage of water, as was once suggested. However, in another desert animal, the kangaroo rat, the entire water economy depends on water formed by oxidation of food.

The camel's body temperature

Most warm-blooded animals maintain a constant body temperature of around 37 to 40°C. When man is exposed to the hot desert environment his body temperature does not increase, although the air temperature may be considerably higher than his own body temperature. Any inanimate object placed in the same surroundings would heat up just as the rocks on the desert surface, which may reach 60°C or higher. Man avoids a rise in temperature in these surroundings by evaporation of water, which appears on the body surface as sweat.

The camel also regulates its body temperature and keeps it from rising beyond a dangerous level by sweating. However, the camel is able to utilize certain variations in the body temperature to save on the amount of water necessary to keep cool. Instead of keeping the body temperature constant as the heat of the day comes on, the camel permits its body temperature to increase slowly until a maximum of almost 41°C has been reached. During this period of temperature increase the camel does not lose much water, while a man maintaining a constant lower body temperature would have to evaporate water continually.

It is clear that the camel would benefit even more if he could start on the morning of a hot day with a body temperature lower than usual. In this way it would take longer for him to heat up to the critical point where he must start sweating to avoid further rise and death. This is just what the camel does, during the cool night he gives off heat so that his morning temperature may be as low as 34°C.

The body temperature of the camel thus regularly varies more than 6°C. Under similar conditions the daily temperature variations in man are around 1°C.

The human body normally contains about 1/3 solid matter and 2/3 of water. Only a small fraction of this water can be lost before serious symptoms occur. The organism reacts with a craving for water which, if unrelieved, rapidly passes into discomfort, uneasiness and irritation. These symptoms are rapidly relieved by drinking water or other fluids.

If the dehydration continues and the water loss exceeds about 5% of the body weight, the symptoms become more serious. There is disturbance of the bodily functions, the salivation becomes scant and the mouth is dry. The tongue sticks to the mouth, and the inspired air penetrates unbearably hot into the lungs. The voice becomes cracked and the senses distorted. The movements become ill-controlled, and judgment and morale is impaired. The stage that has been vividly described as "cotton-mouth" occurs when 6 to 8% of the body weight has been lost.

The symptoms of a water deficit of more than 10% of the body weight are known mostly from reports of men who have been lost in the desert, and those are of necessity rather unprecise. There is delirium, deafness, insensitivity to pain from bruises and wounds, and no blood or exudate appears in cuts in the skin. There is an inability to swallow at about 12% water deficit, after which a man is probably unable to recover without assistance. In the final stages of dehydration there is no recovery; the agony is relieved only by a merciful unconsciousness.

If the heat is not excessive, life may perhaps last until there is 20% water loss. In the desert heat, however, a man will die at 10 to 12% water loss. This has been explained by the American physiologist Adolph as "explosive heat death", because death comes suddenly, associated with a rapid temperature increase.

The explosive heat rise is due to the fact that the blood becomes thicker and more viscous as water is lost. It takes more work to pump the thick blood, the load on the heart increases, and as dehydration proceeds further, a point is reached at which the heart cannot keep up with the increased strain. The circulation then slows down, the metabolic heat is not carried away, and at this point the temperature of the body rapidly increases and death follows in a short time.

Defence against explosive heat death

In view of this knowledge it was curious to find that the camel could tolerate losing as much as 30 % of its body weight during water deprivation in the hot desert. To the trained physiologist this seems rather incredible, and we were interested in the physiological peculiarities that enabled the camel to escape explosive heat rise.

If it were possible for the camel to maintain its usual blood volume during dehydration and not give up water from the blood, the normal circulation could be maintained. The blood volume can be measured by injecting a non-poisonous dye into the blood stream and see how diluted this dye becomes when it is evenly distributed in the blood fluid, a procedure which is completely harmless. In a camel that had lost 50 litres of water during water deprivation (20% weight loss) the reduction in blood volume was less than 1 litre. The rest of the water had therefore been taken from the tissues and tissue fluids. This places the camel in a much better position than other mammals, in which the thickening of the blood is the main cause of the explosive heat death.

Although the camel needs less water than other mammals, he has to drink if the feed does not contain much water.

(Cont'd on page 63)

Photo J. Dragesco and F. Petter.

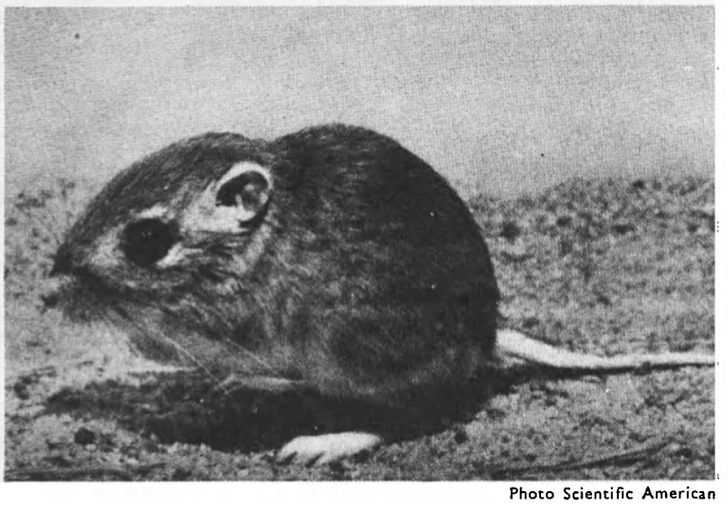


Photo Scientific American

DESERT ANIMALS THAT NEVER NEED WATER. U. S. KANGAROO RAT (RIGHT): AND AFRICAN JERBOA CAN LIVE FOR MONTHS ON DRY SEEDS.

Saharan Art

TRIANGLES & CIRCLES WITH MAGIC MEANING

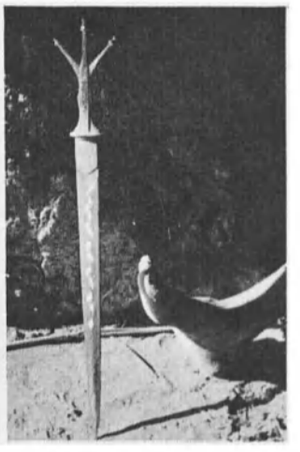
by Jean Gabus

OF all the nomads that wander over the sands of the Sahara there are none poorer than the Nemadi.

They possess no tents and most of the time their camp is nothing more than a hole in the sand or the shelter afforded by a small bush. In order to placate the treacherous shifting sand dunes the Nemadi give them affectionate names. One they will call *Nebket Naada,* "the Round Dune, its sand so soft for the night is a gazelle's robe"; another, *Elmourich,* the Forest (there are scarcely three thorny bushes and a few tufts of alfa grass but their enthusiasm is so great over so much shade and miraculous freshness that they add: "Our camels will be as cool as at the wells!"). A third dune they will call *Haz ould el Routh,* a Fat Pasture—though it needs the eye of a starving camel or of a poet to spy the rare tufts of scrub buried here and there beneath the sands.

When water is nowhere to be found and the camels collapse on the Nemadi hunting grounds, the women trace a clover-shaped cross in the sand. This is the "Terejanna" or bird of paradise which will intercede with the Prophet on behalf of the luckless hunters.

And when a potter from the Azaouak of the Hoggar region anxiously watches over the baking of her pitchers and pots (a whole week's work) and endeavours to reduce the strength of the flame with balls of millet or to shore up the cunning structure of camel droppings with green twigs, she too quickly draws in the sand the sign of the "good eye".



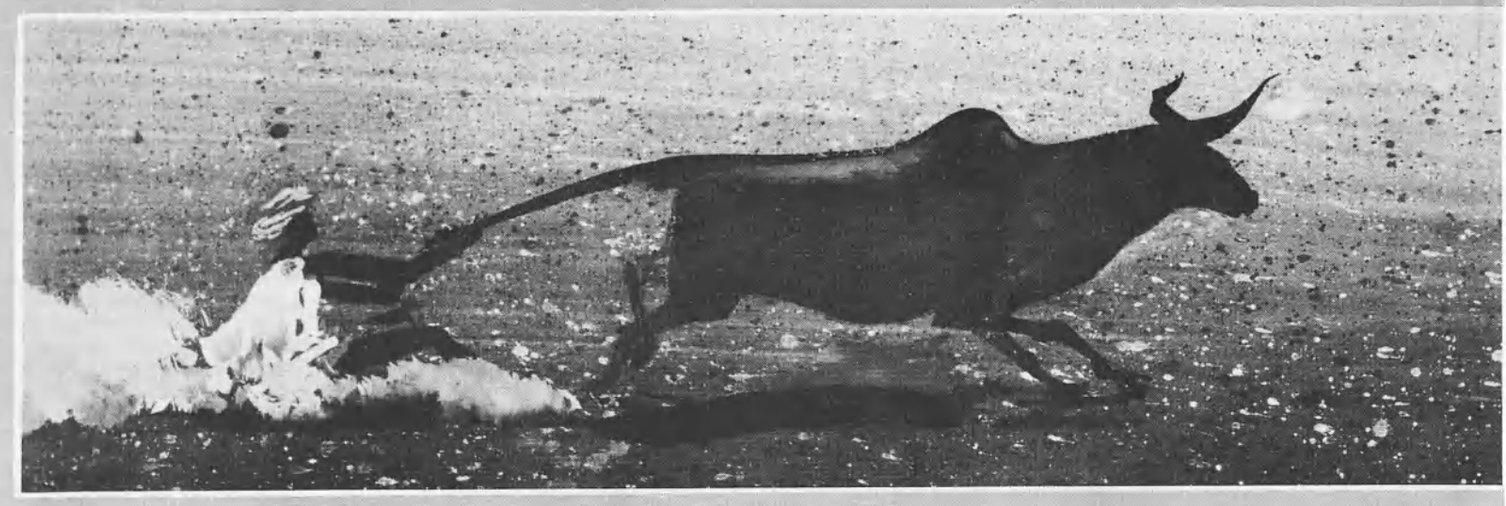
In jewellery, pottery, weaving and other crafts, magic and symbolism form an essential part of the decorative art of the Saharan peoples. Photos copyright by Jean Gabus.

These patterns in the sand, which are an appeal to the gods and spirits and to which are attributed powerful magical qualities, are basic elements of Saharan decorative art.

In the Sahara, art finds itself between two poles—Islam and the great desert. It would seem that it could be no more than a form of expression imported from the Orient, an art of illuminators or of rugmakers applied to leather, wood and metal. In most cases this is what it undoubtedly is—a *(Cont'd on page 36)*

Between 1942 and 1953, Jean Gabus, director of the Ethnographic Museum at Neuchâtel, Switzerland, made eight expeditions to the Sahara, from Mauritania in French West Africa to the Fezzan, Libya. Dr. Gabus is the author of "Au Sahara", of which the first volume, "Les Hommes et leurs Outils" (Men and Implements) has already appeared. Two other volumes — "Les Arts et les Bijoux" (Arts and Jewels) and "Les Techniques et le Mobilier" (Crafts and Furniture) — are in preparation. Photographs by Jean Gabus published in this issue (most of them taken from "Les Hommes et leurs Outils" published by Editions de la Baconnière S.A., Boudry-Neuchâtel) are copyright. Drawings by Hans Erni on pages 34 and 35, also copyright, are from "Initiation au Désert" by Jean Gabus, published by Editions Rouge S.A., Lausanne, Switzerland.

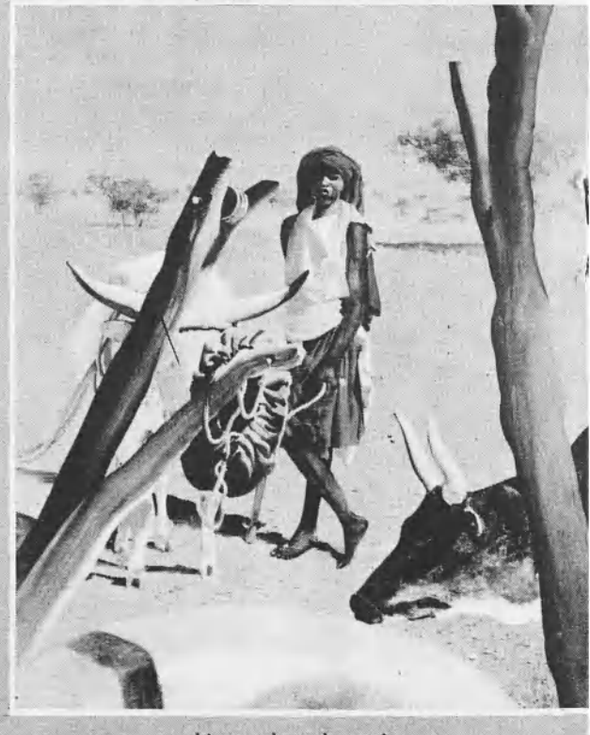
SAHARAN ART *(Continued)*



Sporting with a Zebu

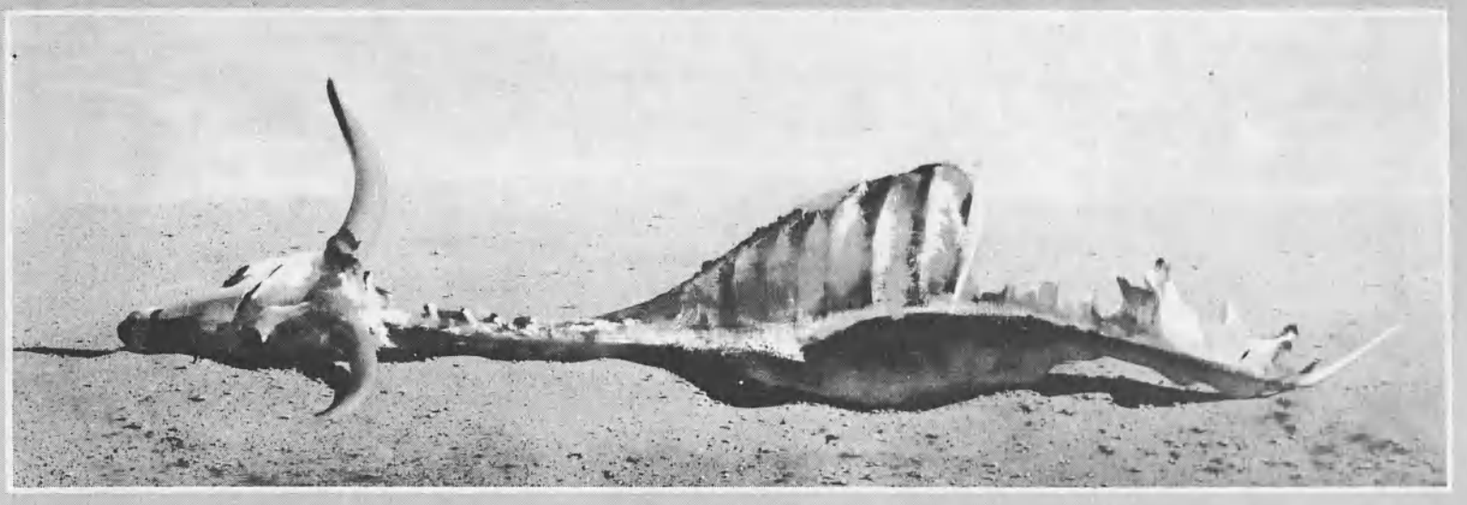
Jewels for a Moorish woman

Mederdra women at the well

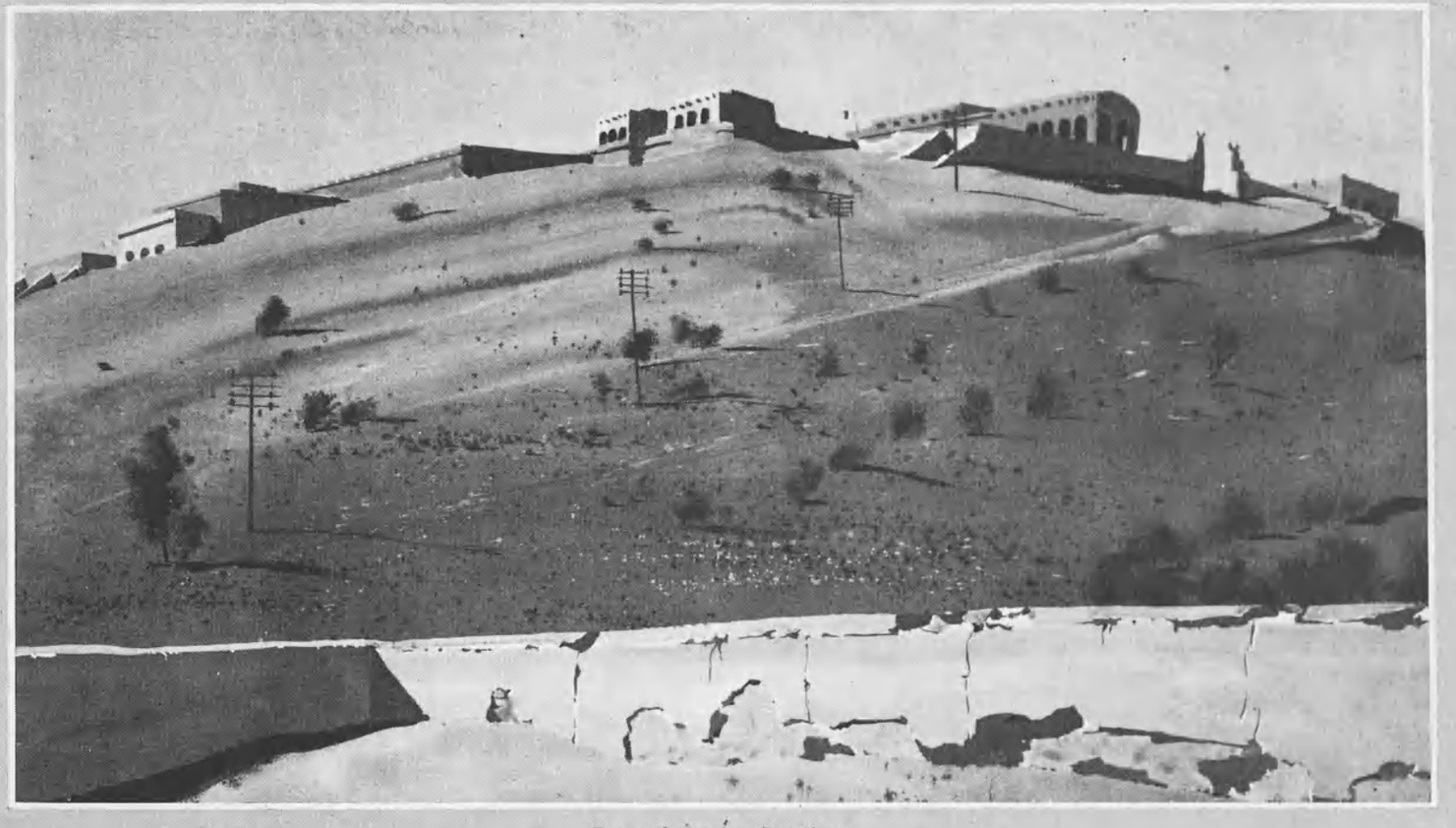


Livestock at the oasis

SWISS ARTIST HANS ERNI SKETCHES DESERT LIFE



A Zebu's whitened bones



Desert fortress at Boutilimit

Blacksmiths at work

Song in the desert

ALL DRAWINGS COPYRIGHT

SAHARAN ART (Cont'd)

FEAR OF THE 'EVIL EYE'

"minor art" which as André Malraux said "does not express man's spirit."

Yet amid the jigsaw of its geometrical patterns and despite the limitations of a conventionalized style almost devoid of feeling, the personal, individual character of Saharan art is everpresent. The people of the Sahara tell us their story through their artists, the Tuareg "Enhaden" and the Moorish "Mâlemin".

They tell us of their wells, their flocks and gazelles, of their houses practically devoid of furniture, of God, of the "Peoples of the Empty Spaces", the "Sons of the Devil", the evil eye, scorpions and vipers, thirst and the sand-blown winds.

Saharan art might be little more than an art of fear if it did not also reveal man's positive stand face to face with the Universe, and express his subdual of superior, hostile forces through rites and symbolic decorations which are as moving as prayers written with threads of wool on a carpet or engraved by chisel on copper or silver.

Viewed in this light the art of these shield decorators is nearer to conquest than to submission. The nomad ends by believing that the wind, the tracks and the wells can be tamed, that agreement can be reached with the gazelles, the ostriches, the bustards and the guinea-fowl. He feels freed from some of his fears, and master of the desert and his own destiny.

All marabouts (holy men) are well acquainted with the magic attributed to numbers and letters. Each letter has a sacred meaning and letters are used to compose Koranic amulets and talismans. As Jean Marques-Rivière has written, "Islamic tradition, like the Talmud, teaches that the letters of the alphabet are the essence of things, related to the celestial spheres, the signs of the Zodiac and the four elements." Thus we find the Saharan people, and particularly the Moors, using letters as sacred decorative motifs in sheepskin rugs, jugs, wooden bowls, jewellery and even on the doors and walls of houses.

Numbers are used to inscribe the name of Allah on rings, pectoral plaques, pendants and bits of paper placed in special leather bags. The number five is considered particularly sacred. It represents the famous hand of Fathma as well as the five sacred personages (Mohammed, Ali, Fatima, Hassan and Hussain). It also symbolizes Providence and the epitome of Law and Religion. Because of this it recurs not only in jewellery but in practically every form of ornamentation.

Berber crosses and certain leather bags (tassoufra) show the multiple use of the number five in decoration as pearls of silver, as dots in the centre of a pattern, as cruciform motifs, as five-pointed stars and as two crosses of St. Andrew transformed into an eight-pointed star.

Fear of the evil eye is extremely common among the nomad tribes of the desert and particularly so among the Berbers. To ward off its evil influence, the triangle (a form of stylized eye) is one of the protective symbols used. It appears, for example, in the form of heavy pectoral pendants worn in southern Morocco, the Sudan and other regions of the desert. The Tuaregs, who have carried the art of making camel saddles to the height of perfection, adorn their saddle bags to an amazing extent with leather triangles. They also put a cluster of leather triangles, painted in green, on the tassels and fringes which hang from the saddles themselves.

Against the powers of the evil eye there also stands the "good eye". A mirror, a piece of glass, shining jewellery or stones—anything in fact that glitters will do the trick. All of these substances figure frequently in the decorative motifs of Saharan art. But belief in the magical powers of the "good eye" is so powerful and so much part and parcel of everyday life that it often takes a more utilitarian character than mere artistic expression.

A circle inscribed with a line or a circle with a dot in the middle is often drawn rapidly in the sand to answer a specific need. This we have already seen in the two examples cited at the beginning of this article.

A star drawn on the palm of the hand by Nemadi women on the eve of a long voyage is another way of protecting oneself against the evil eye. Then of course there are many Koranic talismans, known as "kitaba" amongst the Tuaregs, which are little bags of leather or silver containing verses of the Koran, one or several names of God, magic symbols and letters of the Arabic alphabet, numbers, the names of days of the week, of planets and various signs representing the eye.

There are many other ways of warding off the evil eye. The Peuls and Mozambites tattoo inscriptions on their bodies, while on the occasion of certain feasts Tuareg girls paste little green triangles on the paint covering their faces.

We should not assume, however that, because magic pervades Saharan art, this prevents the artists from being realists or even trivial. Thus two matmakers, Aicha and Lalia, who were sitting shivering in front of their tent one icy morning in the Sahara, clamoured for "hot tea to warm our bones" at seven a.m.; then for "three more glasses with plenty of sugar" at 11 a.m., wailing "our backs ache and if we don't regain some strength the brush will drop from our fingers." At three in the afternoon they asked for more tea, this time the five Moorish glasses, "because it is too hot!"

But their old, half-withered hands wove strips of leather into the mats with designs expressing "the young girl's laughter" and "the wings of the turtle dove" guaranteeing that "this will bring happiness to the house."

Then there was Meimouna in the camp of Ould Oumer, Emir of Trarza. Though the symbolic motifs she was painting on a "faro" (sheepskin carpet) were meant to ensure prosperity in her master's house, she seemed in no way awed by the magic part of her art. She spat, blew her nose with her fingers, told a bawdy joke or two and all the while added up in her mind the

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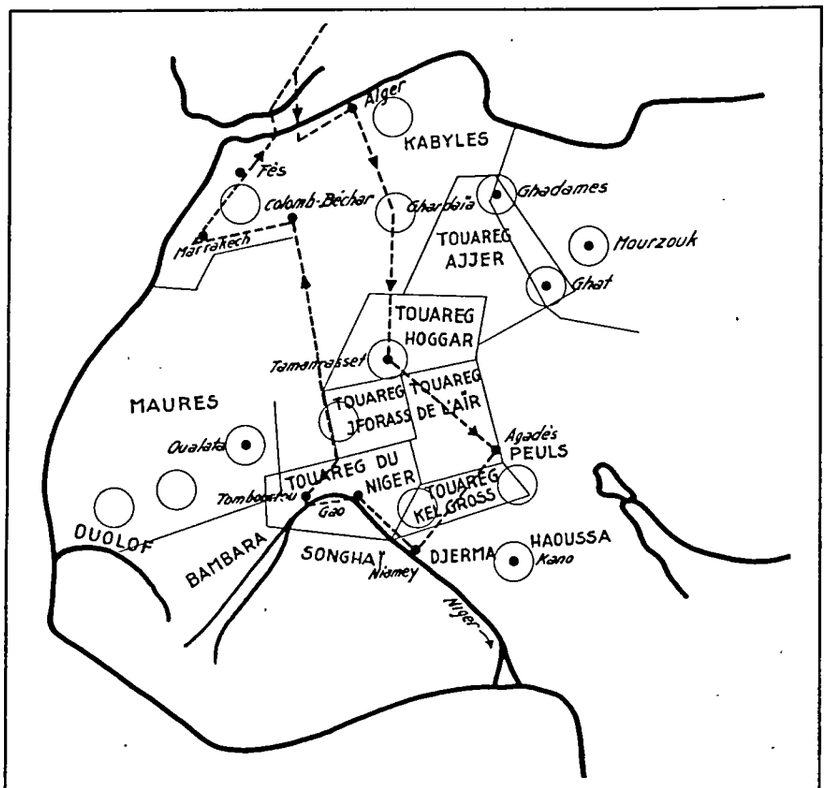
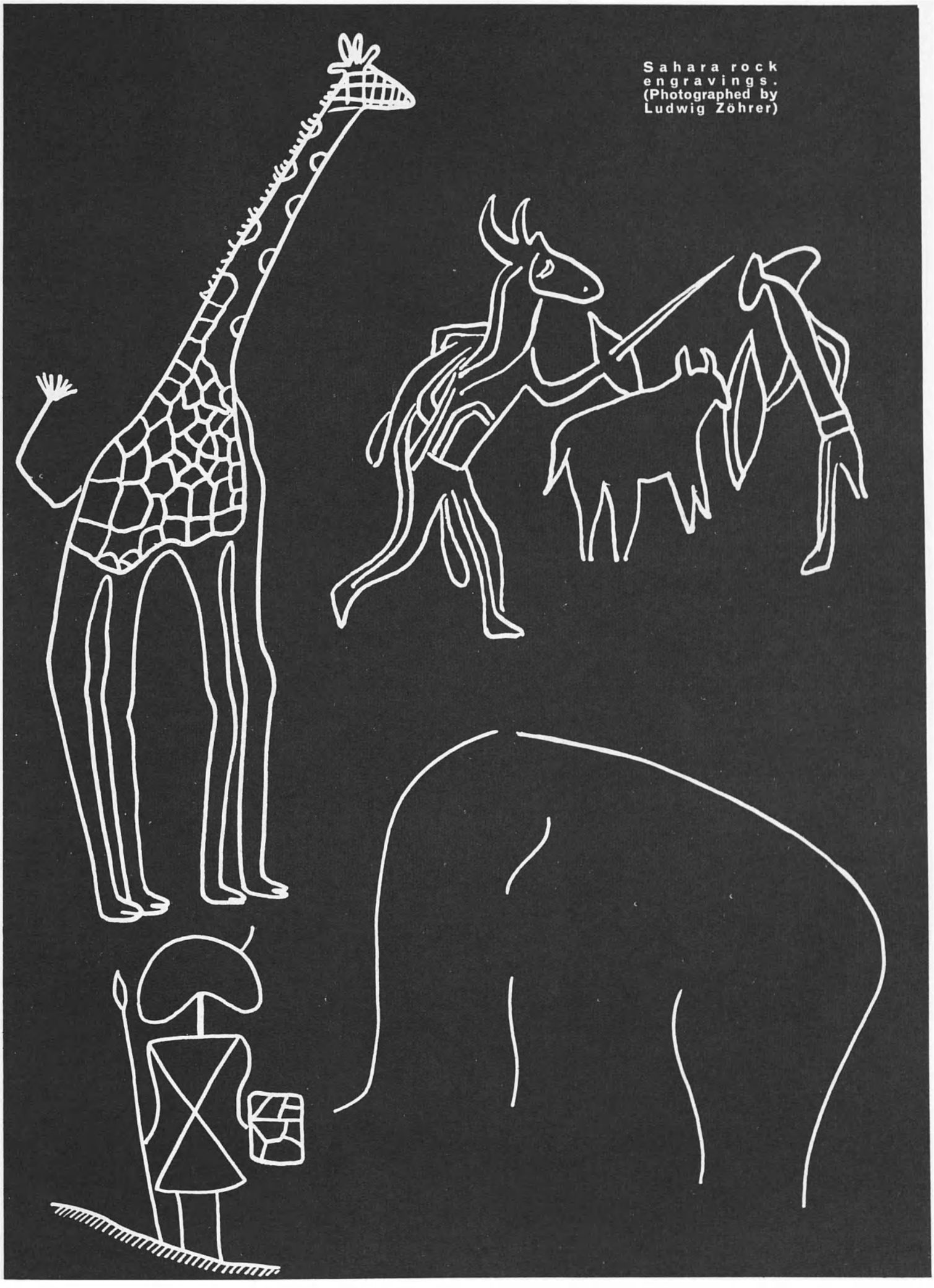
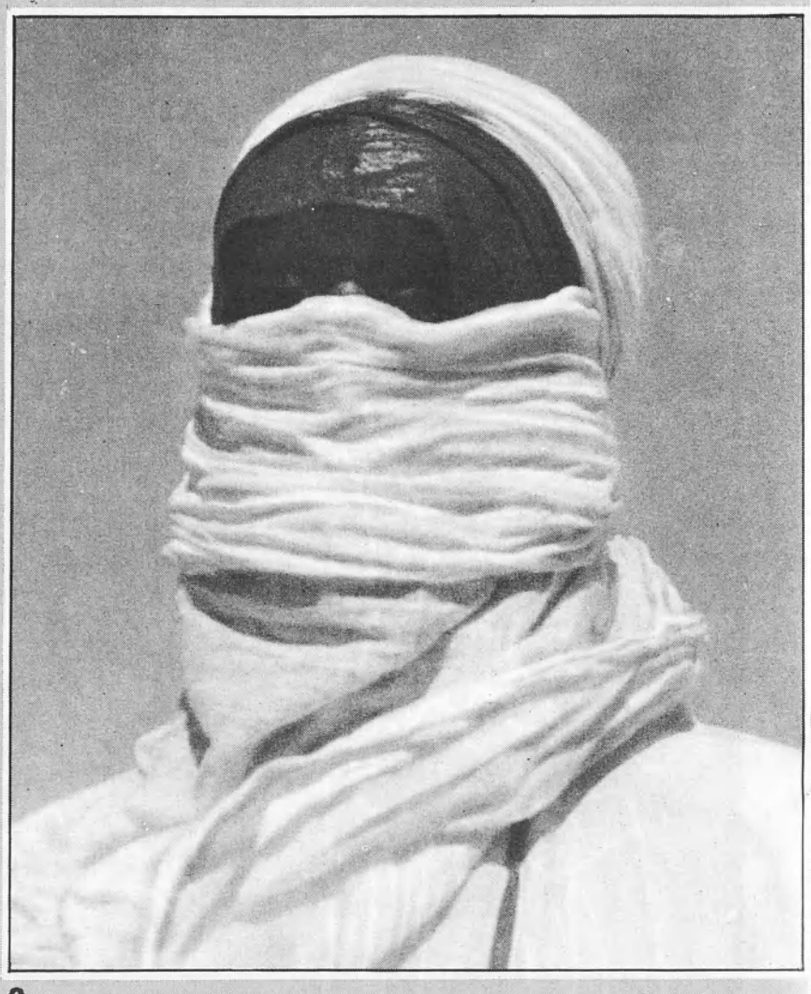


Routes taken by Jean Gabus during the expeditions he made between 1942 and 1953 are shown on this map, together with the names of several tribes and places he refers to in his article. This map, taken from his book " Au Sahara, Les Hommes et leurs Outils ", (Men and Implements) is copyright.



Sahara rock engravings. (Photographed by Ludwig Zöhrer)

1

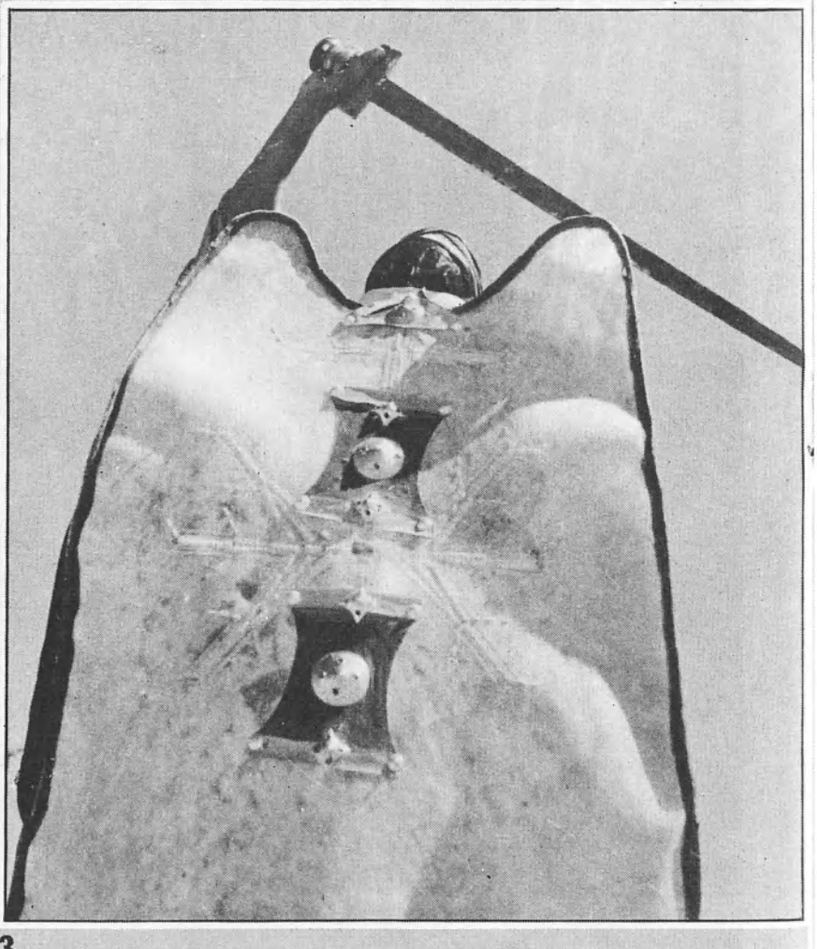


2

'FORGOTTEN OF GOD'

In the middle of the Sahara live the Tuareg tribesmen, a Berber people whose name, given to them by the Arabs, means "Forgotten of God". The Tuaregs however call themselves Imohar or nobles. Mounted on swift mehari (white thorough-bred speed camels) Tuareg warriors can cover unbelievable distances even during the hottest season. Though Moslems, their womenfolk are not veiled; instead the men usually are, so as to protect their faces from the sun and desert winds. Above right, a Tuareg nobleman from the Hoggar region in the south Algerian territories. Above left, a young Tuareg girl. Note huge earrings worn. Cross of Agades tipped with green triangles is painted on face for festive occasions and dances. The triangle helps to ward off the "evil eye". Right, a camel-mounted Tuareg brandishes his enormous shield, called "arar". This famous shield is made from the skin of a whole oryx, a type of gazelle or antelope. Despite the fact that it is heavy and cumbersome the Tuareg takes the greatest pride in his shield. He uses it not only as a weapon but also as a wind and sand break by propping it against his camel's cross-pommelled saddle. The kind of St. Andrew's cross with projections on upper part of the shield is supposed to possess magical qualities and ward off evil spirits.

Photos (1) copyright J. Gabus. (2) copyright G. Tairraz taken from " Le Grand Désert " by R. Frison-Roche and G. Tairraz published by Arthaud, Paris. (3) L. Zöhrer.



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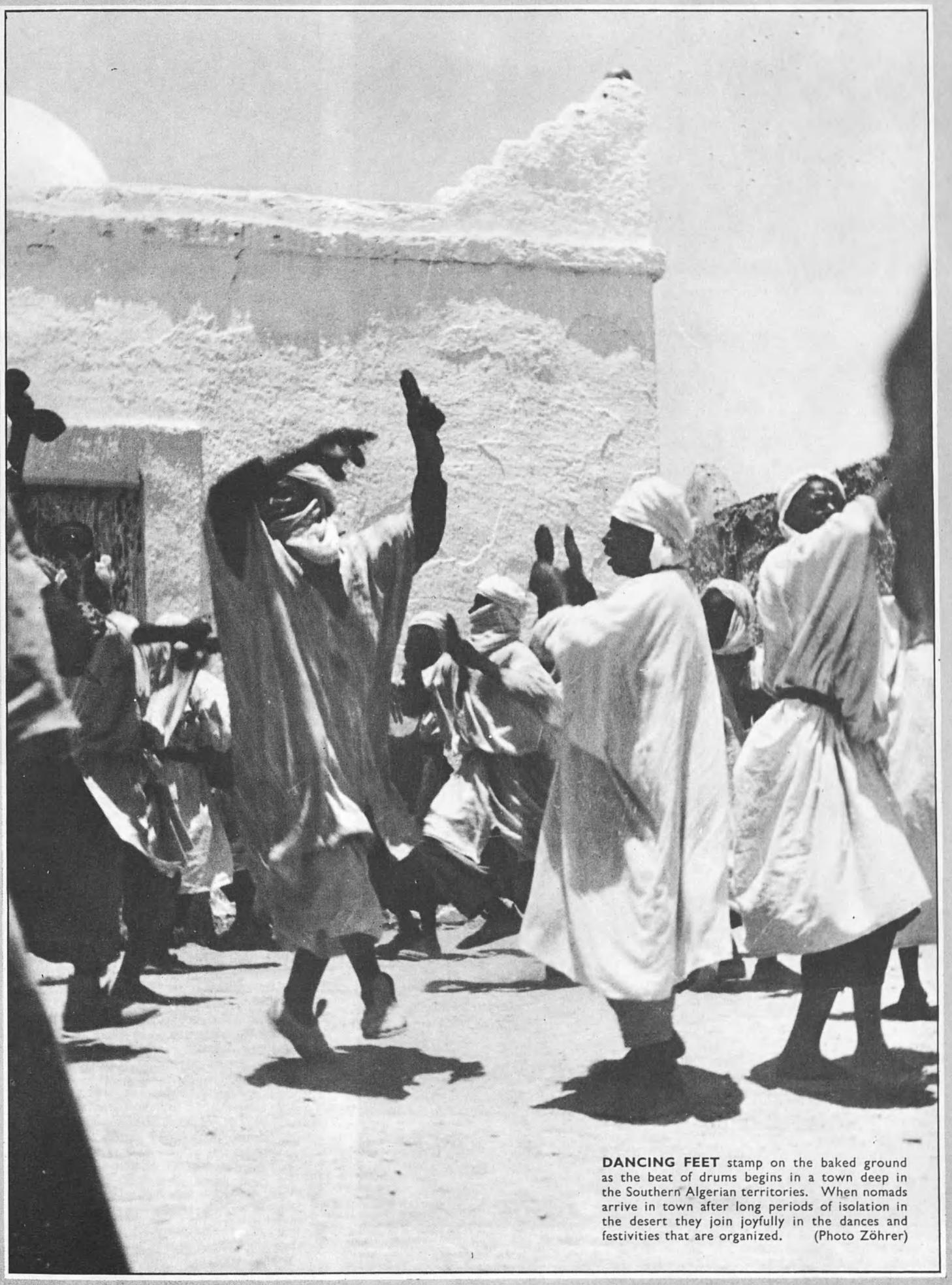
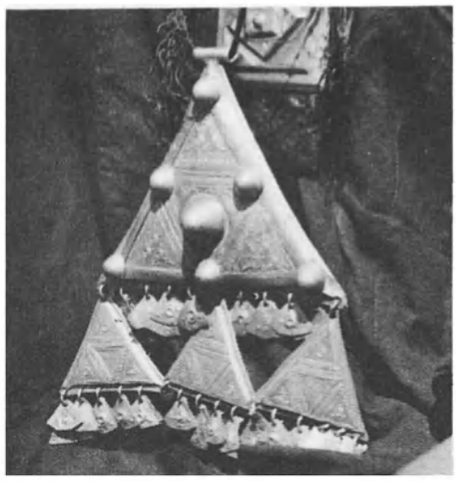
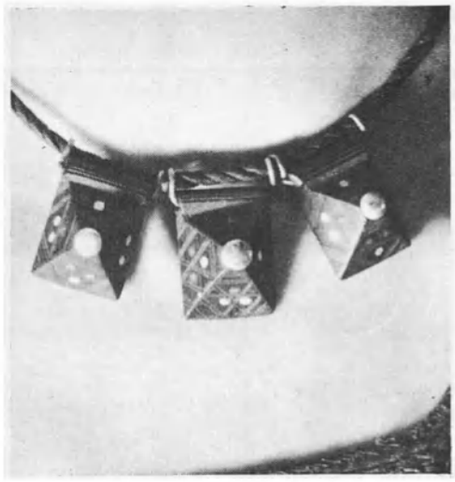


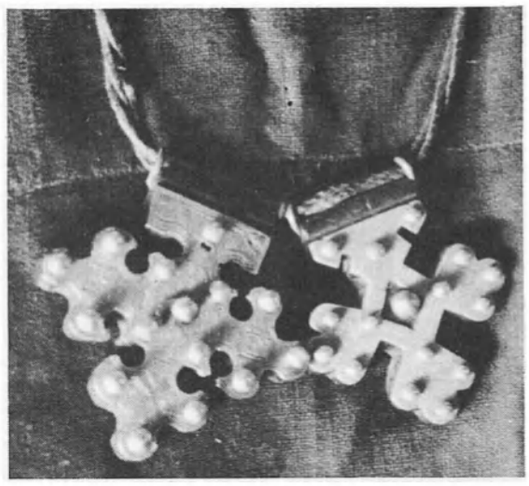
DANCING FEET stamp on the baked ground as the beat of drums begins in a town deep in the Southern Algerian territories. When nomads arrive in town after long periods of isolation in the desert they join joyfully in the dances and festivities that are organized. (Photo Zöhrer)



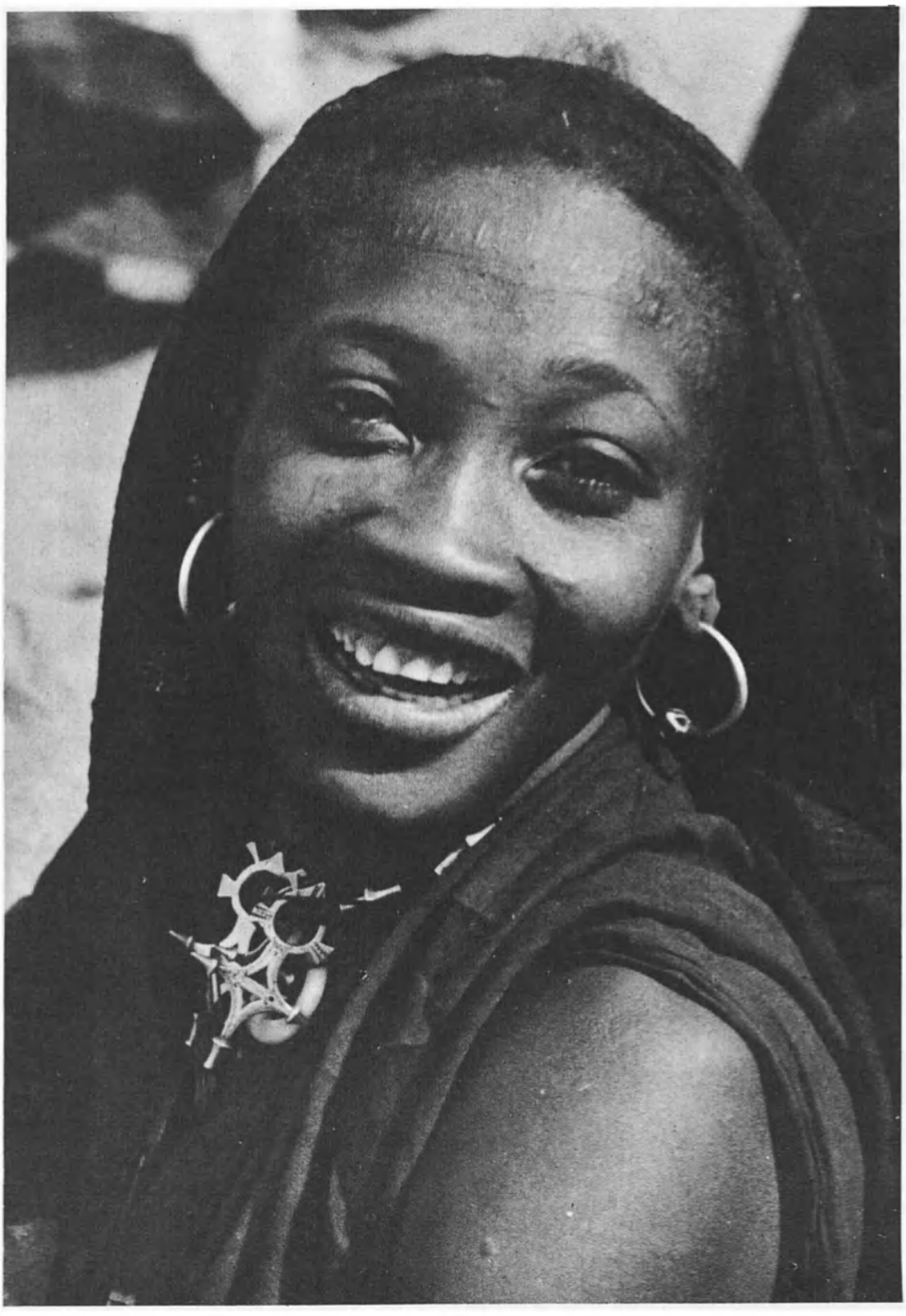
Niger : Large silver pendant from Hoggar



Mauritania : Wooden pendant inlaid with silver



Mauritania : A Trarza cross



Niger : Woman wearing an Agades cross. Everything that glitters—mirrors, glass, shining jewellery and stones—helps to ward off the "evil eye". These objects often figure in the decorative motifs.

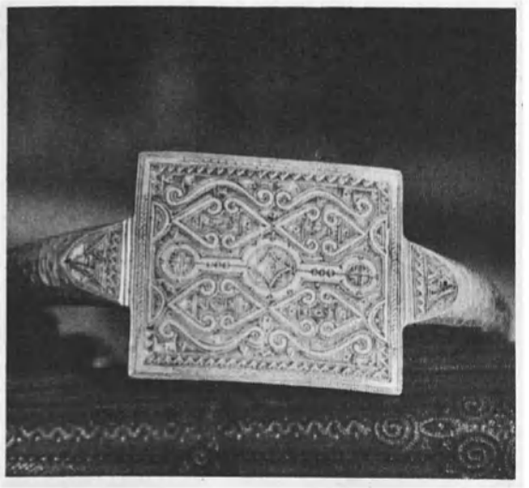
Among the nomads of the Niger calabashes are often the only household belongings. They are decorated with poker-work designs, chiselled or painted. All photos copyright Jean Gabus.

SAHARAN ART *(Continued)*

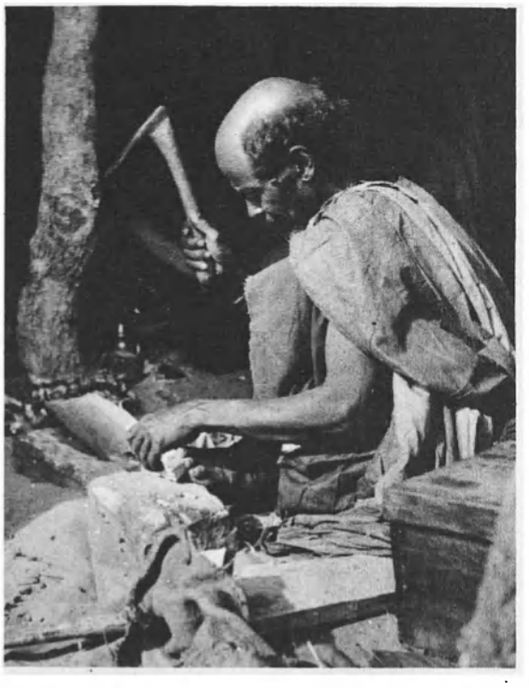
number of yards of blue guinea cloth, the handfuls of sugar and tea and the measures of millet which the work would bring her.

I vividly remember my visit to Oualata in Mauritania. It was once a flourishing cross roads city for caravans from Morocco, Senegal and French Sudan, and the seat of a famous medersa (Moslem university). Today two-thirds of the town is in ruins. But here and there one spies a white door decorated with amazing motifs in ochre, yellow and blue on a red background. The mystical meaning of the designs is now lost except to a few old women who can still explain and even paint them.

One of these women was piously explaining to me the mysterious details of three motifs, "Mother of Hips", "Sacred Stone of Ablutions" and "Lamps of Everlasting Life" whose theme is essentially sexual. Despite



Mauritania : Silver signet ring from Boutilimit



Chest maker at Mederdra. Everywhere in the Sahara artisans work into their wood the symbols of happiness and of fear, which strangers simply see as triangles, circles and curves.

At Oualata, in Mauritania, a potter using his finger as a brush, decorates a house with an ochre coloured paint made from red clay, gum and water. Designs flanking doorway each comprise the same symbolic patterns. In the centre is the " Sacred Stone of Ablutions " surrounded by " The Chain " which protects the house, and around this are the four " Lamps of Everlasting Life " — symbols with a sexual meaning.

the seriousness of her explanations, the slightest trifle, like a shepherd passing by with a calabash of milk, or the cry of a meat vendor, was enough to make her stop abruptly and blurt out: "My stomach comes first. It is more important to get some food into it every day than to put paint on walls."

But triviality on the part of an artist in the Sahara is the mark of a caste which is both feared and despised, as well as the mark of close acquaintanceship with a craft which is half magic. But it is also true that one spoken word too many may arouse the spirits and result in reprisals. The artists firmly believe in the preventive powers of their symbols even when they cannot explain them.

Tuareg decorations adhere closely to the fundamental symbols found in Moorish patterns. The Tuaregs seek protection from the evil eye and believe in the curative and preventive powers of copper and cornelian and in the malefic influence of iron. They believe in infernal creatures inhabiting the Empty Spaces, the Night and the Dunes, against whom they protect themselves by means of rites, amulets and symbolic decorations.

They admit all this but do not ask themselves too many questions. These are the myth-realities of everyday life, the constant small reminders that the winds, the earth, the trees and other substances have changing moods which can be countered by merely taking simple precautions like eating, drinking and sleeping. Through their art they thus reveal the symbiosis or communion with nature which the anthropologist Radcliffe-Brown speaks about. Their religion and the magic which is part of it are deeply embedded in their lives.

To get some idea of the many factors that must be taken into account in making even a simple instrument, let us take a look at a dagger made at Iforas, a frontier zone between the Tuareg country and Mauritania.

First there is the foreign origin of the iron, then the magical properties of the materials used, and then the symbolism of the decoration. But the dagger also tells us the story of the frontier which separates the Moors from the Tuaregs—two distinct ethnic and linguistic groups and two different cultures living almost side by side in the Sahara.

The blade was a diamond-shaped French bayonet sold by a Senegalese rifleman stationed at one of the desert outposts. The handle was Moorish in shape but in Mauritania it would be considered of Moroccan inspiration. The ornaments inlaid in the wood were also based on Moorish techniques of jewellery making: little pieces of silver skilfully worked with the point of a needle into twin "waous" (a U with two tiny curls at the tips) from which a host of varied compositions can be made. There was a cross (often found in Tuareg decorations) but it was quite rudimentary, probably because no traditional handicraft

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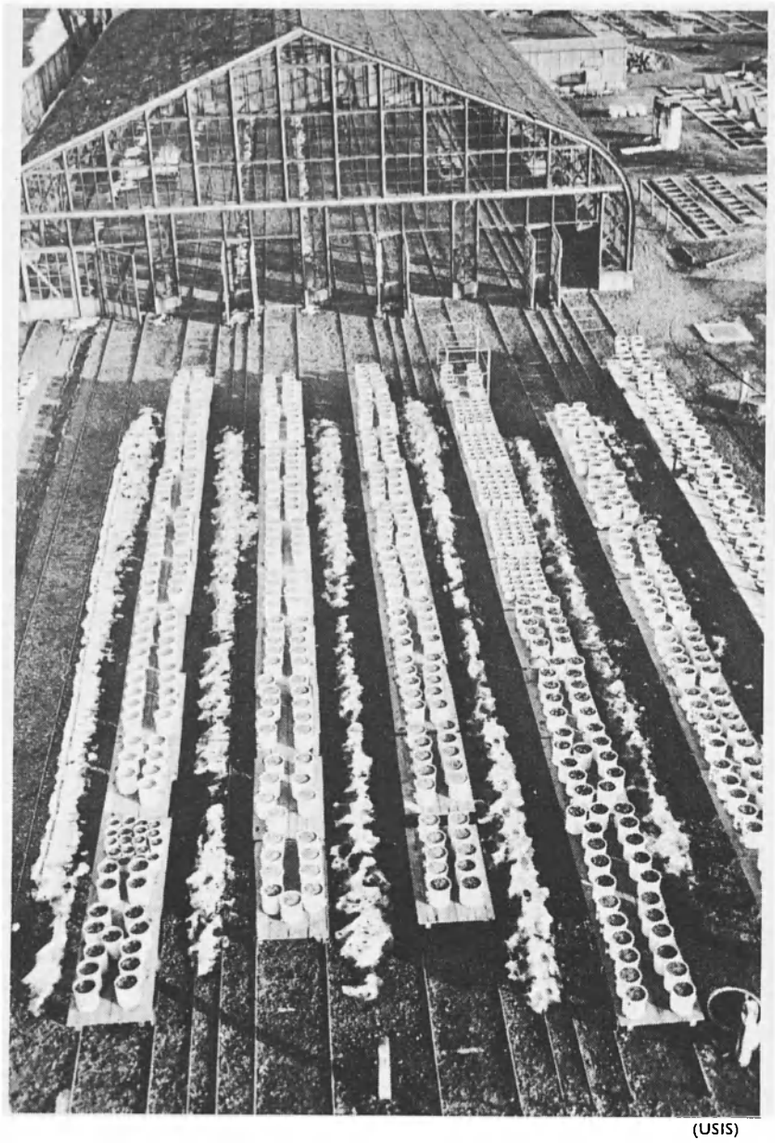
HYDROPONICS:

Farmers grow food crops without soil

by J. W. E. H. Sholto Douglas



(USIS)

Every large city of the globe including New York, London, Paris, Calcutta, Buenos Aires, Rome and Tokyo, could now be made completely self-supporting in vegetables by the large-scale adoption of hydroponics, a new science which enables people to grow food simply without the use of soil. Hydroponics is still believed by many to be a complicated, expensive business, but new simplified methods evolved by scientists in recent years have now made it extremely economical. Tomatoes, rice, potatoes, maize, peas, lettuce, French beans, and a host of other vegetables have not only been grown successfully by hydroponics but yields are sometimes four times as high as those obtained by conventional methods in soil. Photo above right, shows American pomologist (fruit tree expert) growing apple trees in large pots filled with sterile sand to which nutrient elements are added. Above, hydroponicum in Japan.

EVER since the publication in 1798 of Malthus' Essay on Population, there have been periodical warnings that in time mankind would face starvation, owing to the number of the world's inhabitants outgrowing the available food supplies. Fortunately, this grim prediction has not yet come to pass. True, the possibility still remains, but the immense advances made in agricultural science, and the consequent increased production, seem to have staved off disaster—at any rate for the time being. Nevertheless, nothing would be more ill-advised than an attitude of complacency. Although food surpluses may arise in some areas, there can be actual famine in others. The general food problem is as far

Mr Sholto Douglas, Bristish agronomist, has been responsible since 1946 for the development of soilless cultivation at the West Bengal Agricultural Institute and the experimental stations at Darjeeling and Calcutta. Originator of the Bengal methods of hydroponics, he is the author of a book on the Bengal system.

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from being solved as ever, and it is likely to remain so until new methods of producing food in the areas where it is most needed are introduced on a large scale.

One of the most promising of the new methods is soilless cultivation. It is not generally realized that a way of cultivating food crops without using any soil at all has been evolved. Also known as hydroponics—a word derived from the Greek, meaning "water-working", as opposed to geoponics or agriculture, meaning "care of the earth"—this growing of plants without soil has now become a practical proposition. Many successful installations are flourishing in various parts of the world, in all kinds of climatic conditions.

By divorcing food production from the soil, hydroponics enables countries lacking fertile farmland to grow all the crops they need to nourish their people. It is no exaggeration to say that the introduction of soilless cultivation on a large scale can provide the solution to the problem of local hunger. Excellent crops can be grown without soil, at low cost and with a minimum of trouble, in places where conventional methods of agriculture are impossible. By bringing cheap and nourishing foodstuffs within the reach of all, hydroponics offers something of real value to humanity.

Hydroponics is the art and science of growing plants without soil by feeding them on chemical solutions. Crops can be raised in the absence of organic matter simply by giving them in artificial form the nutrients which they usually draw from the earth through their roots. The basic principles of soilless culture are not new. In fact, for nearly a century workers have been producing plants for physiological experiments in their laboratories by the use of similar methods, but until a few years ago nobody had thought of adapting or applying such ideas to practical or commercial food production.

Indeed, the sole object of water culture experiments was to enable the farmer to make better use of his soil. Then, suddenly, amazing results were obtained by Californian researchers who managed to raise crops without any soil at all, by growing them out of doors in nutrient solutions or inert media moistened by cultural infusion. This was the beginning of a new and successful method of crop growing.

The study of crop nutrition began thousands of years ago, long before the time of Aristotle. Ancient history recounts that various experiments were undertaken by Theophrastus (372-287 B.C.), while several writings of Dioscorides on botany and its allied subjects, dating from the first century A.D., are still in existence. The earliest scientific approach to the question, however, was that of F. Woodward (1699), who worked in England with water cultures

(Cont'd on next page)

HYDROPONICS (Continued)

Vision of tomorrow: rooftop farmers

to see whether it was the water or the solid particles of soil that nourished the plants. At the time, it was commonly believed that "for nourishment of vegetables the water is almost all in all". Van Helmont had grown a willow for five years in an earthen vessel containing 200 pounds of soil to which nothing had been added except rain water or distilled water, and had produced a tree weighing 169 pounds at an expenditure of only 2 ounces of soil.

Tomato vines 25 feet high

But Woodward has recorded his disagreement with the current ideas. He wrote that "earth and not water is the matter that constitutes vegetables". His conclusion was based upon experiments in which he grew spearmint in glasses containing water from various sources, methodically recording the initial and final weights of the plants and the total amount of the liquid consumed. He observed that the addition of an ounce and a half of garden soil to the water increased the "terrestial matter" and consequently the growth of the plants.

Handicapped as they were by lack of equipment, investigators of those times could make little progress. But modern chemistry, built up during the seventeenth and eighteenth centuries, subsequently revolutionized scientific research. The experiments of Sir Humphrey Davy, inventor of the safety-lamp, had evolved a method of effecting chemical decomposition by means of an electric current. Several of the elements which go to make up matter were brought to light, and it was now possible for chemists to split up a compound into its constituent parts.

By 1842, a list of nine elements known to be essential to plant growth had been made out, and the discoveries of the German workers, Sacha and Knopp, in the years 1859-65, resulted in the development of a technique of soilless culture in the laboratory. The addition of a chemical to water was found to produce a nutrient solution which would support plant life, so that by 1920 the laboratory preparation of water culture had been standardized and the methods of conducting trials were well established.

Until 1928, however, the phrase "crops without soil" was virtually unknown. The value of the discoveries had not been realized. In that year, Robbins, working at the New Jersey Experiment Station, suggested that sand culture had possibilities for research and commercial work in horticulture. This was followed by a similar announcement from Biekart and Connors, of the same institution. At Ohio State University, Laurie issued an account of the trials carried out there with washed sand in greenhouse culture.

A further step was taken in 1929 when Professor W. F. Gericke, of the University of California, succeeded in growing tomato vines 25 feet in height. Even the most incredulous critics were impressed. A new factor had suddenly appeared and was making itself felt in the world of practical and scientific agriculture. Such a novel technique was bound to attract attention. The American press hailed it as one of the most colossal inventions of the century, reporting with magnificent abandon that farmlands had become relics of the past. Many extravagant and irresponsible claims were made for the new science, which could not at that time be justified.

Although hydroponics had broken laboratory bounds and in one stride entered the world of practical horticulture, it was still an involved and complicated technique. Because of this, and the fact that the different functions of the various parts of the necessary apparatus were imperfectly understood, early sensational publicity threatened to destroy its future. Unscrupulous adventurers attempted to "cash in" on the discovery by selling useless equipment at fantastic prices to the ignorant or the credulous. Fortunately, experienced research workers and scientific institutions continued to give hydroponics considerable thought and attention.

Despite the excellent reports of its efficacy as a means of crop production, hydroponics had not spread among the general public. This was mainly due to the elaborate apparatus and equipment required for the operation of the methods advocated up to quite recently.

Planting in rock cinders and sand

The world war of 1939-1945 resulted in a spread of hydroponic cultivation to many different areas, and a general realization of the immense possibilities of soilless growth began to dawn upon agronomists everywhere. In 1946 research studies were commenced at the Government of Bengal's experimental station at Kalimpong, in India, with the object of introducing a simple and practicable technique, suitable for popular use.

In 1948 it was possible to announce the development of the Bengal system of hydroponics, which incorporated substantial modifications of all previous practice. The plants could be grown in troughs built from any suitable material, and filled with a mixture of five parts of rock chips, leached cinders, gravel, or broken bricks, of five-eighths to one-quarter inch grade, and two parts of sand. Substitutes, such as peat, could also be employed. The nutrients are applied dry, at regular intervals, in stipulated ratio to the area of the bed surface, either as fertilizer grade chemicals, or as synthetic resins. Packeted powdered compounds or tablets can be utilized. After application, the salts have to be watered in with a light spray of water, if there is no rain.

No elaborate equipment is required for a hydroponicum of this kind, and extensive use may be made of local indigenous materials. Simple rules must be followed by the grower, but if these are carefully adhered to, anyone can use the method without special knowledge or training. The Bengal system of hydroponics, adapted and modified for different climatic zones and conditions, is today rapidly spreading throughout the world and becoming very popular on account of its comparative simplicity, economy, and its easy installation.

Greenstuff in any odd corner

Today hydroponics is an established branch of agronomical science. Progress has been rapid, and the results obtained during the past five years in various countries, including the work conducted in Bengal, have proved it to be thoroughly practical and have some very definite advantages over normal soil culture. The two chief merits of hydroponics are, first, much higher crop yields, and second, the fact that it can be used in places where ordinary agriculture or gardening is impossible.

Not only is it a profitable undertaking, but it enables people living in crowded cities to grow fresh vegetables in window boxes or on house roofs. Town residents and workers in industrial settlements often have verandahs, backyards or pavements of which they can generally make little use. By means of hydroponics all such odd corners can be made to yield a regular and abundant supply of greenstuff. Other possibilities are factory roofs or disused roads. Not only town dwellers, but also country residents, can profit from soilless culture. Deserts, rocky and stony ground in mountainous districts, or barren and sterile areas can be made productive at relatively low cost. It is no exaggeration to say that hydroponics can mean as much to the landless worker as the abolition of slavery did in the past.

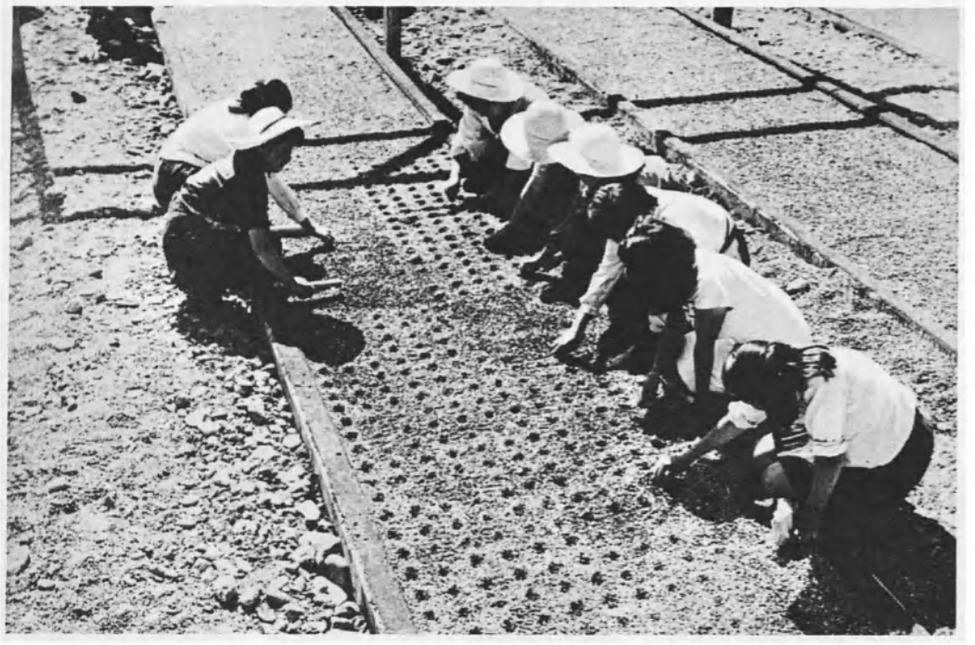
(Cont'd on page 46)

BOON TO WORLD'S VAST ARID LANDS

Millions of tons of nourishing foods could be grown in hydroponicums. Not only could immense barren lands be made productive but crops might also be raised in sterile and arid regions such as the Sahara Desert, the wastes of Arabia or Central Asia, the rocky highlands of Japan or the underdeveloped territories of Australia, Canada and Patagonia. Left, on Tokyo hydroponic farm some of crops are started in 5-acre green-house, one of largest in world. Right, US Department of Agriculture agronomist cultivates experimental soybeans at Beltsville, Maryland horticultural station. (Photo USIS)

LETTUCE & TOMATO ON GRAVEL SAND

The U.S.A. is the original home of hydroponics. Here it has been developed more than in any other country. Many techniques are used but very often they are too complicated for the general public. But where equipment can be afforded results have been excellent. A large part of the tomato crop of California, for example, is raised by hydroponics. U.S. Army and Air Force now have Hydroponics Branches to provide fresh vegetables to overseas personnel. Left, Air Force man inspects tomato crop in Hawaii; right, workers grow lettuce on Army Hydroponics Farm at Iwojima in Pacific. (Photo USIS)



MODEL 'FIELD' of gravel in concrete basins is planted by Japanese women at U.S. Army Hydroponics installation, Chofu, Japan. American hydroponic farming in Japan started with 16 five-acre units devoted to vegetable growing. (USIS Photo)

Apart from the advantages already mentioned, there are others, in particular quick growth combined with relative freedom from soil diseases, and very consistent crops, the quality of the produce being excellent. There is also a considerable reduction in growing area, weeds are practically non-existent, while standard methods and automatic operation mean less labour, less cost and no hard manual work. As many plants can be raised out of season, better control of crops naturally results; moreover there is no dirt and no smell. Waterlogging never occurs, owing to good drainage.

Nor does the use of hydroponics alter the taste of a crop in any way. In fact, the piquant savour of soilless-cultured produce cannot be found anywhere else in agriculture. There is no other distinction between a chemically grown plant and a naturally raised one in point of flavour, nor have analyses shown any vitamin content differences.

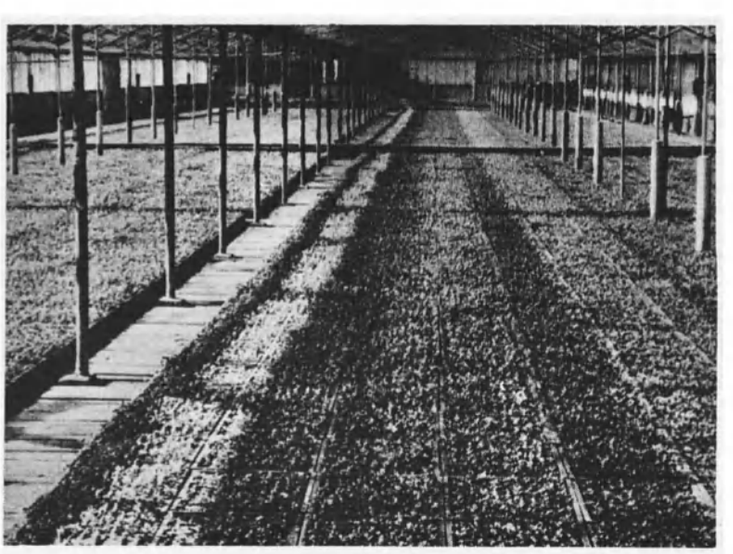
The real development of soilless cultivation began when, having broken laboratory bounds, it was taken up by government departments and commercial organizations. The first great achievement came when Pan-American Airways decided to establish a hydroponicum on distant and barren Wake Island in the middle of the Pacific Ocean, in order to provide the passengers and crews of the airliners with regular supplies of fresh vegetables. In 1945 the British Air Ministry took steps to commence soilless culture at the desert air base of Habbaniyah in Iraq, and at the arid island of Bahrein in the Persian Gulf.

Some of the most successful installations have been those at military bases, notably in British Guiana, Iwojima and Ascension Island. American headquarters in Japan started with 16 five-acre units devoted to vegetable growing, while various oil companies in the West Indies operating on barren or isolated islands, especially off the Venezuelan coast at Aruba and Curacao, have found soilless culture invaluable for

BETTER RESULTS FROM HYDROPONICS

Table shows some yields obtained by hydroponics as compared with those obtained by conventional methods in soil. Other successful crops grown in hydroponicums include: peas, broad beans, onions, cabbage, oats, soya beans, cucumber, brinjal or egg-plants, squash or vegetable marrow, wheat, turnip, carrot, flax, great millet, millet, black beans or dal, gram or chickpea, radish, scarlet runner beans, chillies or peppers, sponge gourd, bitter gourd, pumpkin, sugar-cane.

Crop	Best agricultural yields	Hydroponic yields
Tomato	12 lb per plant (U.S.A.)	27.4 lb per plant (var. Sutton's Majestic, University of California)
	11 lb per plant (U.K.)	16.4 lb per plant (var. Stonor's M.P., Jealott's Hill Research Station, England)
	10 lb per plant (India)	22.5 lb per plant (var. Best of All, Hydroponic Research, India)
Rice	Average per acre: 5-50 tons 900 lb per acre (India) 3,000 lb per acre (Italy, Japan)	Average per acre: 150-200 tons 5,000 lb per acre (broadcast) 9,000 lb per acre (transplanted, West Bengal)
Potatoes	30 tons per acre (California)	65 tons per acre (Dr W. F. Gericke, California)
	12-15 tons per acre (U.K.) 9 tons per acre (Bengal)	70 tons per acre (Agricultural Station, Kalimpong, India)
Maize	2,000 lb of grain per acre (North Bengal)	6,000 lb of grain per acre (Bengal)
Lettuce	9,000 lb per acre (North Bengal)	21,000 lb per acre (Hydroponic Research India)
Beetroot	9,000 lb per acre (North Bengal; Calcutta Exptl., Sectors)	20,000 lb per acre (Calcutta Exptl. Sectors)
French beans	210 lb from 1,000 sq. ft trough (var. Dwarf, Canadian Wonder, North Bengal)	588 lb from 1,000 sq. ft trough (var. Dwarf, Canadian Wonder, Hydroponic Research, India)
Cauliflowers	10,000-15,000 lb per acre (Bengal)	32,000 lb per acre (Bengal)
Lady's fingers	5,000-8,000 lb per acre (Bengal)	19,000 lb per acre (Bengal)



CELERY GROWING at Montebello, California. In this hydroponics garden, celery seedlings are grown in sand and sub-irrigated with a nutrient solution. Here and in several other states of the U. S. A. extensive commercial hydroponicums have been set up. (USIS Photo)

ensuring that their employees get a regular ration of greenstuff.

In the continental United States itself there are extensive commercial hydroponicums, especially in Illinois, Ohio, California, Indiana and Florida. New Yorkers are taking increasingly to skyscraper gardening. Russia, France, Canada, South Africa and Germany are among other countries where hydroponics has received attention. The English carnation growing industry has partly switched over from soil to soilless methods.

It is also of interest to note that a primitive form of hydroponics has been carried on in Kashmir for centuries. Visitors to that state will have observed light frameworks of branches, covered with rotting vegetation, floating on the numerous lakes. Excellent crops are raised by the local peasantry from these rafts which provide both water and nutrients to the growing plants. The simplified Bengal methods are rapidly spreading in Southern Asia, the adjacent areas, and South and East Africa. Australia and New Zealand have also expressed great interest in these new techniques.

Wastelands could bloom

In fact, soilless cultivation, conducted according to the new simplified methods, can make all the large cities of the globe, such as New York, London, Paris, Calcutta, Buenos Aires, Rome and Tokyo, self-supporting in all vegetables, thus leaving the available fertile country farmlands free to concentrate on cereal production. Millions of tons of nourishing foodstuffs could be grown in hydroponicums. Not only could immense barren lands be made productive, but crops might also be raised in sterile and arid regions, such as the Sahara Desert, the wastes of Arabia or Central Asia, the "badlands" of the Middle West of America, the rocky highlands of Japan, or the undeveloped territories of Australia, Canada, and Patagonia.

It is not claimed that hydroponics should replace agriculture, but it has been proved beyond doubt that waste land, rocks, even house-tops and back-verandahs—anywhere that sufficient sunshine and water are available—can be made to bloom and bear at little cost in money and trouble.

Where water is scarce it will be better conserved by running the available supply into controlled hydroponic beds than by dissipating it recklessly over the earth, as is done in ordinary irrigation, and so losing over half in evaporation.

To sum up: hydroponics has already reached the stage where it is a practical proposition; it is profitable in almost any conditions; and it is invaluable as a means of food production in countries or areas which have not enough fertile soil to feed their population.

The above article is a condensed version of a long study which originally appeared in Unesco's quarterly scientific review "Impact of Science on Society", Vol VI, No 1, March 1955. Copies of "Impact" are available from Unesco National Distributors at $. 50; 2/6 and 125 francs a single issue; annual subscription $ 1.75; 9/6; 450 francs.

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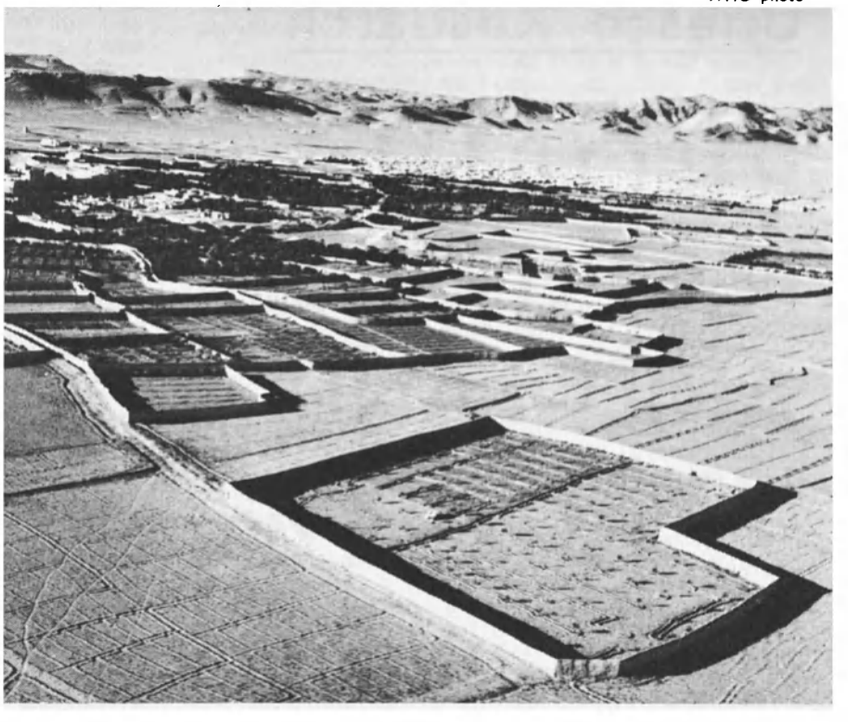
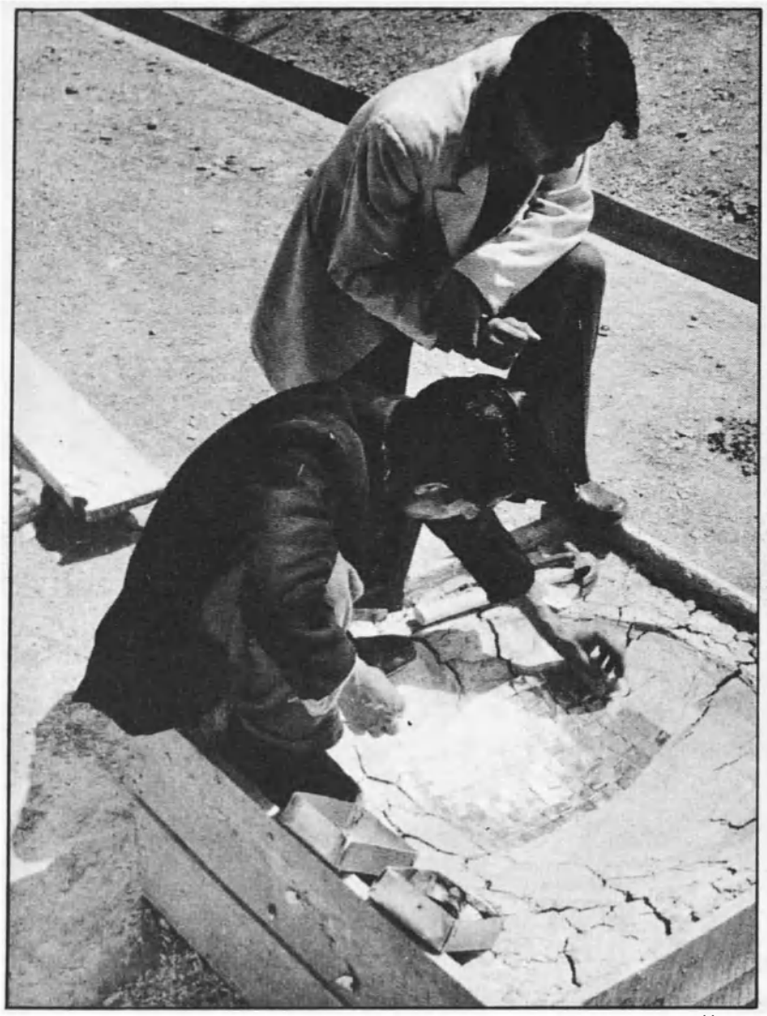
IT NEVER RAINS BUT IT POURS

Contrary to popular belief rain is not completely unknown in the great deserts of the world. When desert rains do come, they often descend in brief but torrential downpours. Rainfall in the desert is so undependable though that permanent streams cannot exist. (Rivers like the Nile that flow through deserts obtain their water from sources beyond the desert area.) But here and there among the most forbidding of desert wastelands an occasional green oasis flourishes. Water usually comes from underground streams which seep to the surface and permit vegetation and trees to bloom. Photo, above, was taken in Algerian oasis after flash storm flooded the area. Arab inhabitants quickly took to makeshift rafts. Another aspect of the desert countenance is shown in photo, below, of the ancient oasis city of Palmyra in Syria with its carefully tended palm groves. In walled enclosures (foreground) are young palms protected from the searing desert winds.

WHO photo





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PROBING NATURE'S ARID LAND MYSTERIES

by Dr. H.I.S. Thirlaway

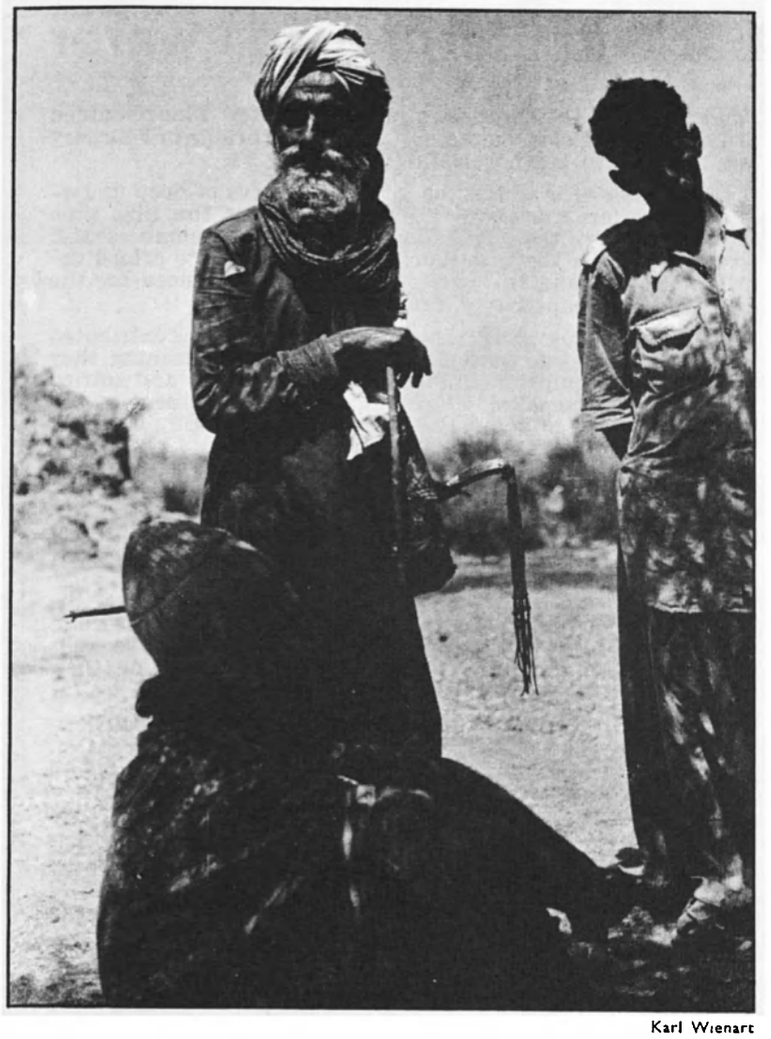
WHAT strikes a traveller going north from Karachi on the southern coast of West Pakistan to Lahore up in the Punjab or wandering over the Baluchistan plateau, is the vastness of the barren land that stretches with little variation as far as the eye can reach. The oases inside this desert zone are the irrigated and cultivated patches of land on both sides of the rivers, the canals which flow from the rivers, and the isolated orchards which thrive on water from underground springs or brought to them by karezes (man-made underground channels), from a meagre reservoir hidden many miles away in the bleak hills. But many a farmer who has no access to water either from spring or reservoir, tills his land, dumps any manure he can get, then waits for the merciful heavens to pour down.

This is the arid and semi arid land of West Pakistan, a zone with an area of nearly 250,000 square miles, covering Baluchistan, Sind and the major portion of the Punjab. The total annual rainfall does not normally exceed five inches in Baluchistan and is less than ten inches elsewhere in the country excepting the extreme northern portions where the rainfall is nearly fifty inches in the year.

The development of the arid lands in Pakistan, and for that matter anywhere else in the world, entails scientific research and application on many problems including the procurement of more water either from the sky above or the ground below, the conservation of the available water, and its economical use for the growth of plants. The utilization of the huge quantity of energy from the sun's rays beating down on these lands is another problem of great importance.

In some of the schemes designed to develop the productive capacity of the arid zone of West Pakistan, the national Meteorological Service is immediately involved. The two most obvious problems of interest to the meteorologist are the increase of natural rain by artificial means and the utilization of solar energy, though his services are appreciated when given in co-operation with other research

Dr. H.I.S. Thirlaway, British seismologist, is a member of the Geology Department of the University of Sydney. Since 1951 he has been working in Pakistan with a Unesco team of scientists which is co-operating with Pakistan in harnessing the country's natural resources, both above and below ground. He has been particularly associated with the development of Pakistan's Geophysical Observatory at Quetta.



Karl Wienart

SHEPHERDS GUIDE THE SCIENTIST

The size of a raindrop, a subterranean dynamite explosion, and the measurement of water flow and of the sun's energy don't seem to have much in common. But for scientists working in Pakistan's Geophysical Observatory at Quetta they are raw materials from which solutions to Pakistan's arid zone problems will be found. Since 1951, a Unesco Geophysical Mission has been operating in Pakistan under the U.N. Expanded Technical Assistance Programme. It has co-operated with Pakistani scientists in harnessing the country's natural resources, both above and below ground. Photos show some aspects of the research in which they collaborated. Left, experimenting with a home-made solar cooker—clay paraboloid inside a packing case, covered with pieces of cigarette tinfoils. Successful cookers are already available—at a price. Experts showed villagers how to make their own cheaply. Centre, studies were made of minimum water requirements for plant growth. Here, Pakistani scientist checks temperature radiation thermometer. Right, Pakistani shepherds became invaluable guides to Unesco geophysicist co-operating with Pakistani scientists in magnetism surveys which will lay foundation for future intensive prospection of mineral resources.

The Pakistan Meteorological Service has established at Quetta, with technical assistance from UNESCO, a geophysical observatory which is already equipped for research in problems not only of artificial rain, water economy of desert plants and use of solar energy but also in arid zone hydrology with special reference to underground water resources.

The Meteorological Department was keenly interested in finding whether artificial increase of rain over the arid areas was feasible and if so whether it was economical to launch on a long scale and long term project.

Dr. Fournier d'Albe, the UNESCO expert from France who worked with the department for nearly three years, set about this problem in a methodical manner. He first established five stations in Karachi, Hyderabad, Lahore, Peshawar and Quetta for taking regular bi-weekly samples of the air near the ground. These samples were analyzed at the Quetta Geophysical Observatory and inferences were drawn about the natural concentration of hygroscopic particles.

Of all the aspects of cloud formation and rain, there is only one that man can hope to modify. Changing the dimensions of a cloud or increasing its water capacity is beyond human power—at present. But if all the water in the cloud does not fall down as rain, just because the cloud lacks suitably big water droplets, this defect can be remedied. The cloud can be charged with particles hygroscopic in nature, which will form big droplets—about fourhundredths of a millimeter in diameter—which will grow at the expense of the minute smaller droplets in the cloud to raindrop size of about a millimeter in diameter. This is the principle behind seeding the clouds with hygroscopic particles.

One has to know first, however, whether any deficiency or lack of big hygroscopic particles actually exists. The results of Dr. Fournier's analysis of the hygroscopic particle content of the air of West Pakistan brought out the futility of any scheme to increase rain over Sind, the southern province of West Pakistan. Here there are already too many of the hygroscopic nuclei present, and the causes for scanty rainfall are to be accounted for by shallow cloud formations. But the field looked promising in the central and northern Punjab where the lack of nuclei coincides with formations of cumuliform clouds—the type which readily use up the supply of material used for aiding big drop formation.

The experiments were conducted, one in Mardan in July 1953 and the other over the central Punjab in the monsoon of 1954. The Mardan experiments brought out the inadequacy of ground seeding with sprayers of salt solution but indicated clearly that the seeding of the atmosphere from the ground with the most readily available hygroscopic substance namely common salt, was not quite ineffective. A new technique was devised at Quetta by Dr. Fournier and the team of young Pakistani scientists to seed the atmosphere directly with salt particles of the required size.

Careful calculations showed that if a salt particle sent up from the ground has any chance of reaching the cloud base, it should weigh between one thousandth and one hundredth of a microgram. Salt had to be ground to this size if any use was to be made of it. Also salt, being hygroscopic, had to be kept dry during its preparation into powder and up to the time of its leaving the generator at the ground. For this reason, the grinding of salt was done at Quetta where the humidity of the atmosphere was very low at the time of preparation. The ordinary grinders for domestic use in Pakistan were found to be ideal instruments for powdering the salt lumps to particles of the required size. Empty kerosene tins were purchased, the seeding material was packed in them, and the tins sealed against outside air.

The technique of salt dispersal was designed with a view to cheapness, effectiveness and the availability of all materials in the country itself. The final set-up turned out to be very satisfactory. An ordinary silversmith's blower was fitted to the top of the tin containing the salt particles through a bent inlet tube carrying a gauze basket containing burning charcoal. Another outlet tube was fitted to the tin and air was forced in at high pressure by means of the blower. The air stream that rushed out of the tin, was warm, thanks to the hot charcoal, and carried with it the salt particles. The heat given to the outgoing air was meant to give the particles an initial lift before they are carried up by the turbulent eddies in the atmosphere near the ground. A series of tests showed that by this method, one tin full of salt particles could be sent up in less than three quarters of an hour. This meant dispersal of nearly one thousand million particles

(Cont'd on next page)

Shock-waves track underground water

per second ! The whole mechanism only cost 75 Pakistani rupees, or about £8 sterling.

On the roof of the Meteorological Office in Lahore and the High School building in Jauharabad in the Thal area about 200 miles west northwest of Lahore, the blower mechanism for seeding with salt particles was in operation from early morning till sunset on days when the wind blew from an easterly direction. The Lahore station was in charge of Mr. A.M.A. Lateef and the Jauharabad station under Mr. S. I. Rasool, both young and enthusiastic scientists who worked under Dr. Fournier from the early days of his mission in Pakistan. Seeding was done at Lahore and Jauharabad on 39 days during the two months' period of the trials.

The increased rainfall in the seeded areas has induced optimistic views about the efficacy of this new technique. Statistical evaluation of the results has borne out that there was a significant increase in the rainfall over the seeded areas when checked with the rainfall of the previous forty years over the seeded and adjoining areas. Considering that not more than 5,000 Pakistani rupees were spent for the whole project, including allowances to the staff and purchase of equipment and materials, the method appears indigenously suitable and further proposed tests to confirm the 1954 results for the same period in 1955, should help in evolving a general scheme for artificial rainmaking on a routine basis for the arid areas of Punjab.

The long stretch of land flanked by hills, beginning from Mastung in the state of Kalat and extending southward to about 30 miles past Mastung, is a valley where barren fields and green orchards alternate every few miles. The orchards round Mastung grow on water fed into them from deep-seated underground springs. The fields to the south are at the mercy of the seasonal rains.

Explosions from dawn till dusk

EARLY in February 1955, the seismology section of the Observatory under my direction, took their instruments to this valley and with the co-operation of the Geological Survey of Pakistan, determined the thickness of the gravel layers which store water.

This typical upland valley zone about 25 miles long by six miles wide south of Mastung, was chosen for the work at the suggestion of M. Chleq of the UNTAA, who was operating a pilot project in the area, and the work was financed by the Baluchistan States Union.

Excellent co-operation and team spirit between the Observatory headed by Mr. Moiduddin Ahmed and the Geological Survey headed by Mr. Mannan Khan, and the supervision and assistance which M. Chleq and I were able to give resulted in a thorough searching for the knowledge that could lead to Pakistan's most precious mineral—water.

The method employed is called by seismologists "refraction shooting". It consists in recording, at a central station, the time taken for the shock waves produced by a series of dynamite explosions at a distance of 100 yards to a mile, to reach the special detectors buried a foot beneath the surface. The further the explosions from the detectors, the deeper the layers which transmit the shock waves. For example at distances up to 1,000 feet between the explosions and the detectors, the shock waves were transmitted by the water table about 50 feet below the surface of the valley. The time taken for the shock waves to reach the detectors can be measured in thousandths of a second since the instant of the explosion is recorded by the breaking of an electric cable wrapped round the dynamite. The depth of the water table is calculated from the time intervals so measured.

Similarly at distances between 1,000 and 5,000 feet the shock waves received on the recorder were found to have been transmitted along a rocky layer between 400 feet and 600 feet below the surface. From the geological conditions seen at the surface, this deep layer can be regarded as the "floor" of the valley and the thickness of the material lying on this floor gave a measure of the amount of water bearing gravels available for tapping by tube wells.

Day after day, for nearly four weeks, regular explosions from dawn to dusk broke the age-old silence of the valley. It was wintertime and only a few watchmen were left in the mud villages clustered round the sides of the valley where drinking water flows out from limestone rocks. The poor folk in these villages, who cannot afford warm clothing, had migrated to the warmer plains. The few who remained tilled the dry fields, hoping for the seasonal rains in February and March to begin germination.

With tube wells to tap the known resources of deep underground water, irrigation will be possible for the first time in this valley, the population will grow in numbers and wealth, and for the first time, they will be able to afford the warm clothes and fires which will remove the need for the wasteful unproductive annual migration.

It was to this object that the seismologists contributed their quota of information as at sunset every evening they stored their equipment in tents, lit their lamps and settled down to a welcome pot of tea to the accompaniment of the rhythmic drone of the portable generators charging batteries ready for the next day's "shooting".

How thirsty is a fruit tree?

FOUR weeks of investigation throughout the length of the valley enabled contours of the underground structure to be drawn accurately and thus helped to site tube wells in the most productive places. The seismologists and their bangs gave way to the drillers and their rigs.

When water is found and developed by irrigation engineers, the work of the scientists would seem to be at an end. All that remains is for the farmer to grow his produce. But all over the world the tendency is to use too much water in irrigated areas. Rights to such a precious commodity are jealously guarded.

How much water does a fruit tree need? The scientist must come back again to give the answer. At Quetta Observatory there are 100 fruit trees of 20 different kinds, and of 5 varieties each. To each tree a measured amount of water is given, a great deal to some, very little to others. Each day the growth and condition of each tree is measured and compared. The trees are now three years old. By the time they are 10 years old we will be able to answer much more accurately than ever before, the question "how much water does a fruit tree need ?" The answer will help to conserve the available water resources, and to use them more efficiently and economically.

Before the establishment of the Geophysical Observatory at Quetta, no regular quantitative measurements were being taken in Pakistan of the solar radiation energy reaching the surface of the earth. The atmospheric physics section set up by Dr. Fournier and his Pakistani counterparts at Quetta, began measuring the solar energy over Quetta by means of standard meters. The observations began in October 1952 and are being continued. These constitute an incomparable set of values due to the large percentage of clear sky days at Quetta permitting observations on an average of 330 days in the year. Preliminary analysis of the collected data has been done by Mr. Shafi Ahmed, who is now specializing in this branch. These data provide the basic material required for any serious move to utilize the sun's energy.

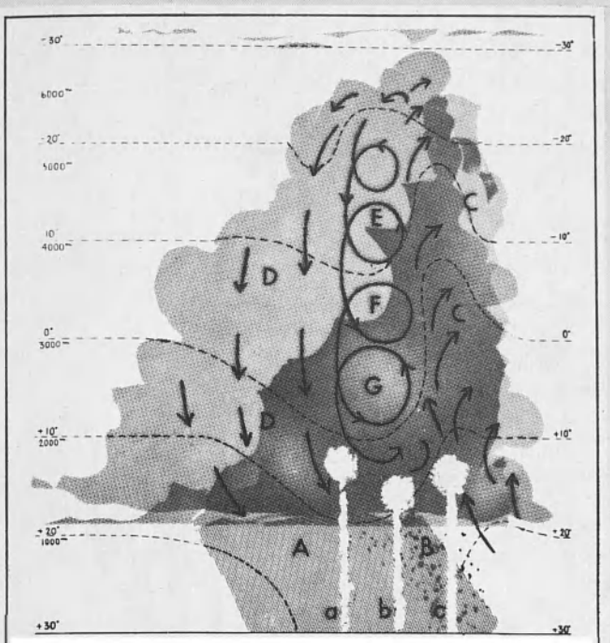
A fabric woven from many threads

A type of solar cooker, both cheap and easy to make out of local materials, has been designed by Mr. A.M.A. Lateef. The soft clay found at the foot of the hills around Quetta was moulded to form a paraboloid inside an ordinary wooden packing case and pieces of polished tin were fixed to the surface. The cooking material is kept at the focal point of the paraboloid by either being suspended from a stand or attached to a straight rod fixed at the centre of the paraboloid. Certain modifications to suit the local domestic use are being made and the cooker is being tested this summer. Successful solar cookers are available—for a price. Our aim is to show the villagers that they can make their own, just as they can make their own houses.

The size of a raindrop, an explosion of dynamite, the measurement of water flow, and the sun's energy, do not seem to have much in common. Yet a group of people at Quetta, working under the same roof, are trying to weave one fabric from these threads, trying to find the key to the fascinating problem Nature has set mankind in the apparently arid and energy deficient areas of the world.

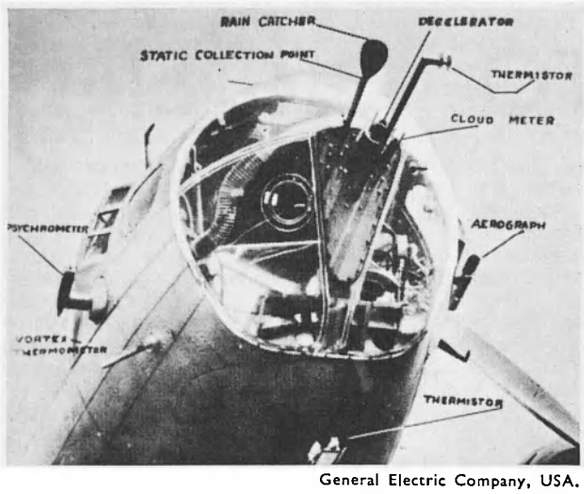
Man's dream down the ages

RAIN 'MADE TO ORDER'

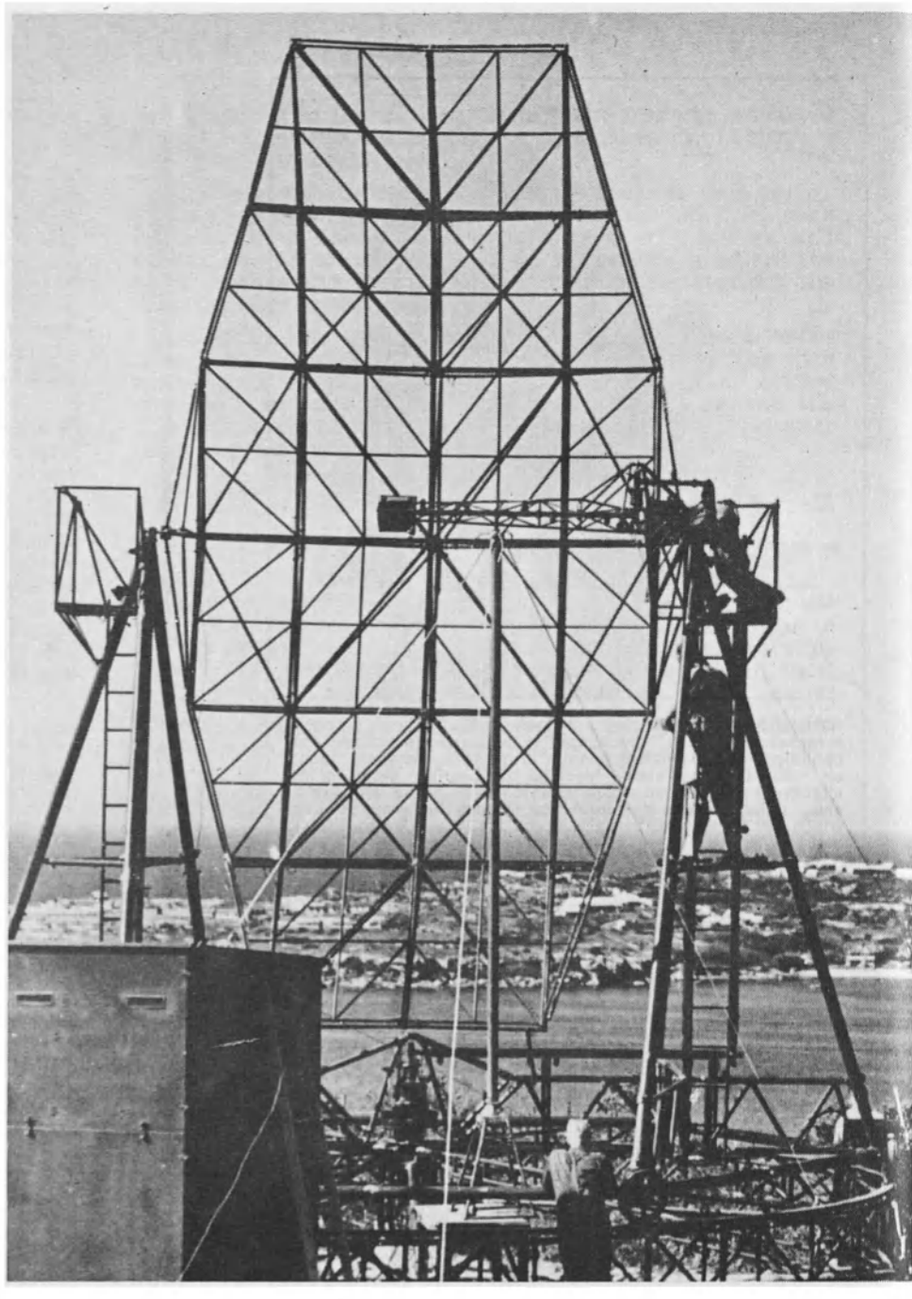


ROCKET ATTACK. With a flash and a "woosh", (right) a rocket soars up to " discharge " a thundercloud before storm conditions become violent enough to produce damaging floods or hail. Drawing above depicts hail-bearing cloud being attacked by rockets in which silver Iodide is mixed with explosive. Iodide crystals start formation of many tiny water droplets which fall as rain. (Photos National Anti-Hail Centre, Paris).

RAIN 'MADE TO ORDER' *(Continued)*



General Electric Company, USA.



SCIENCE WAY UP IN THE CLOUDS

Experiments in the possibilities of rain-making are today going on in many parts of the world. Radar to measure water content of clouds and aircraft for "seeding" them are playing important roles in such experiments. Above, nose of an American aircraft used in rain-making research bristles with a multitude of scientific instruments for measuring atmospheric conditions. Right, radar antenna scans the skies in Australia. Next page, cumulus clouds between 25,000 and 27,000 feet high were "seeded" with dry ice in Australian experiments. Thirteen minutes after operation, cloud in centre billowed up some 5,000 feet and rain began to fall from its base.

Much expensive effort has in recent years been put in attempts to induce rainfall. The experiments have received wide publicity because of the enormous value that a successful method would have, not only in the arid and semi-arid lands of the earth, but also elsewhere when a temporary drought threatens agricultural production. It has been estimated, for instance, that an increase of only ten percent in the annual rainfall on the wheat-producing areas of the western United States would increase the value of the land itself by one half. Even in Norway the cost of the one-month drought last July has been put at about fifty million dollars.

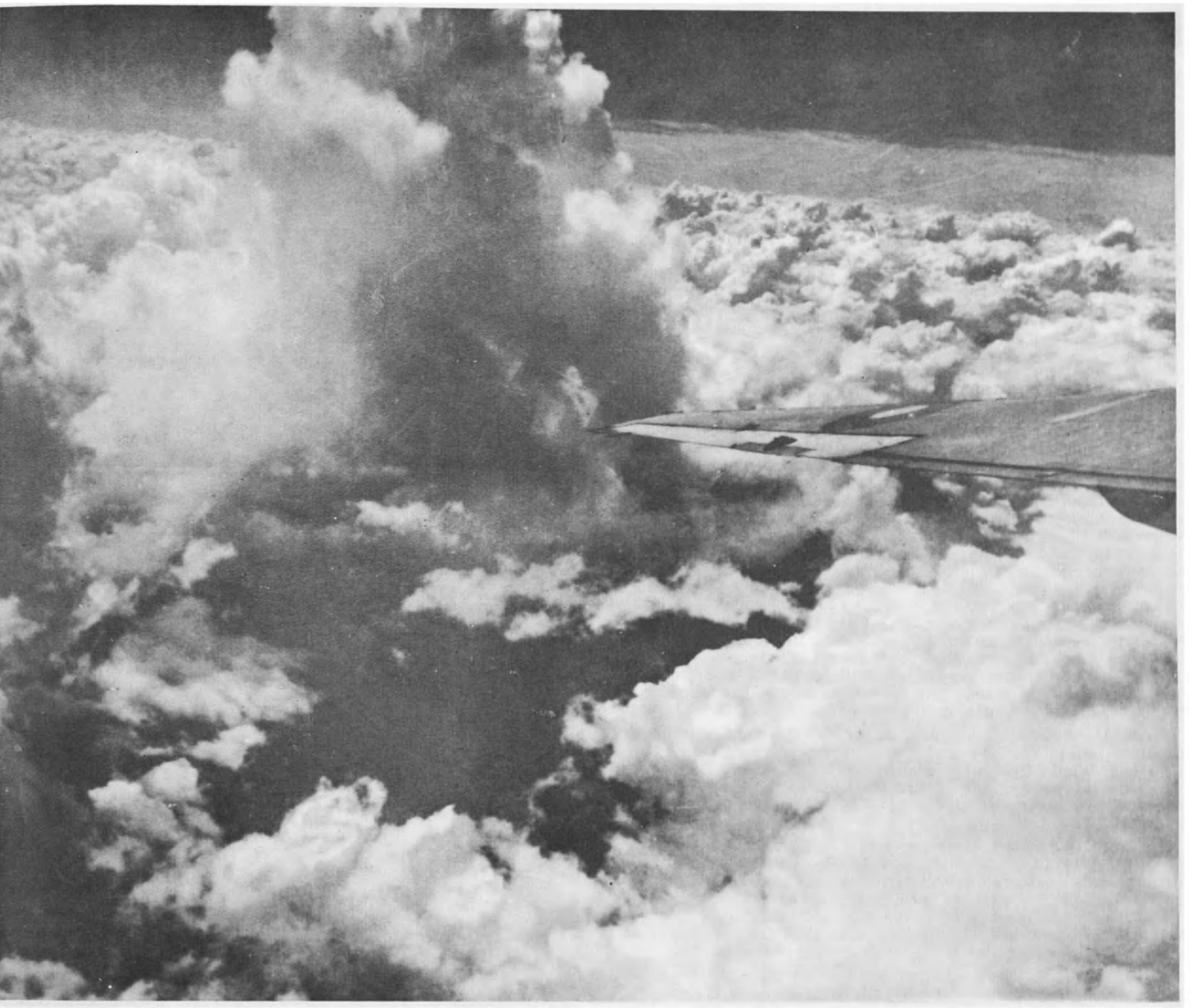
In spite of the many experiments, some of them spectacular, no completely successful method of rain-making has yet been perfected. Droughts are still inevitable and the arid lands are still arid. This means that it is impossible today to use any method that is absolutely certain to give results. On the other hand the experiments are in many cases encouraging. The World Meteorological Organization at Geneva, one of the Specialized Agencies of the United Nations, has called the results "inconclusive" but in a 1953 preliminary report recommended that "new scientifically designed and rigorously checked experiments be undertaken in all regions where there is a possibility of success".

Several limitations on the hopes for rain-making are well established. In the first place, a cloud is needed and no man can make a cloud. Indeed there are many types of thin and hazy clouds which cannot possibly produce rain, either naturally or artificially. Unfortunately such clouds or a burning clear sky are characteristic of the deserts—so that where rain is most needed there is generally least hope of creating it.

In the second place, experiments which have seemed successful have usually been done with the towering and bulging "cumulus" clouds, that are characteristic of thunder-storms, and with some other types of clouds that are natural producers of rain. Thus the chief effort has been to coax the rain from such clouds over an area where rain is needed and where the land-owners are willing to pay the cost, instead of allowing the clouds to drift farther and shed their rain elsewhere. Thunder clouds have also been attacked in order to start the rainfall earlier than normal and before storm conditions become violent enough to produce either floods or hail.

These are some examples of what are at present considered the most promising conditions for success in rain-making. They have little relation to areas where rain seldom falls. The report of the World Meteorological Organization, based on a critical study of results in five areas of the earth, uses these words: "The most favourable meteorological conditions for the artificial inducement of precipitation are to be sought in regions and during seasons where natural precipitation is most likely."

The methods used for inducing rainfall are based on two theories of the natural formation of rain. The first applies in general to the temperate and high latitudes of the world. Here the beginning of the natural rain-making process in the cloud is the creation of minute ice crystals in the cold upper part of the cloud extending above the freezing level. In some circumstances there may be insufficient ice crystals



(C.S I.R.O. photos)

present, and in such cases an artificial introduction of ice crystals into the cloud may be a means of inducing rainfall. Many experiments on the artificial inducement of rain have therefore been aimed at producing ice crystals in selected clouds.

One well-known method has been to "seed" the clouds with a very cold substance, commonly called dry ice, which is in fact the solid or frozen form of carbon dioxide. The particles of dry ice fall through the cloud and leave a wake of very cold air behind them in which ice crystals form spontaneously. Another method has been to introduce minute crystals of silver iodide into the cloud. These resemble ice crystals in shape and structure and under some conditions have an effect similar to that of ice crystals. Silver iodide may be released as a smoke from generators on the ground or carried in airplanes.

The second theory of natural rainfall applies in general though not exclusively to tropical regions where the upper parts of the clouds do not reach freezing temperature. Here the rain-making process is started when some of the droplets in the cloud are so much larger than the bulk of the cloud droplets that they move differently in the cloud and so collide with the smaller ones. In this way they become bigger until they are eventually large enough to fall out as rain. Thus experiments have been conducted with a view to introducing water droplets into the cloud that are larger than the bulk of the cloud droplets. This has been done by spraying into the clouds either water or very small hygroscopic (water-absorbing) particles, such as salt crystals, which at once form droplets of water.

Interesting results have been reported from Pakistan. In the Northwest Frontier Province near the Khyber Pass, between August 25 and 31 in 1953, jeeps from the Pakistan Air Force sprayed salt solution over the roads leading from the city of Mardan. The expectation was that wind would carry the salt particles from the ground thousands of feet into the air where they would cause drops to form in moisture-bearing clouds. In this case scattered observers reported that the areas around Mardan had a 2-inch rainfall following this experiment.

In September of the same year, tests were also made in Pakistan in which the salt solution was sprayed directly into the clouds. Four of the five flights were unsuccessful, but in the fifth the plane left a wake of showers falling thirty or forty minutes after it had sprayed each cloud.

On the basis of these and similar experiments cloud-seeding by air does not seem economically practical in an area as large as West Pakistan but the use of salt on the ground offers considerable promise. What Pakistan's meteorologists hope to do is to tap some of the clouds that blow over Western Pakistan during the monsoon season by using the hygroscopic action of salt in such areas as Baluchistan and the Northwest Frontier Province where there are very few hygroscopic nuclei naturally present in the air.

In a new series of experiments in 1954 another and inexpensive method for salting the sky was used in the Punjab. The method made use of small hand blowers like those used by silversmiths in the Pakistani bazaars. These generators were set *(Cont'd on next page)*

RAIN 'MADE TO ORDER' *(Continued)*

up at Lahore and Jauharabad and used salt that had been ground to a fine powder in a local mill. This powder was blown into the air from the ground at a rate of about a pound a minute. Eight tons of salt were thus wafted upwards in the course of 39 days and at a total cost of about $1,000. Rain gauges scattered over an area of 1,500 square miles showed that this area received at least fifty percent more rain than did the adjoining regions. (*For a detailed report on Unesco experiments in Pakistan, see page* 48.)

Radar measures growing rain drops

In the Union of South Africa clouds at a temperature below freezing were seeded with dry ice and observation of the cloud by means of radar showed some formation of rain drops but there was no measurement of rain that actually fell. The evidence was that seeding with dry ice did at least stimulate precipitation at an earlier stage than would otherwise have occurred. There were also experiments in British East Africa during the rainy season from January to April of 1952 in which silver iodide was carried into the cloud by a balloon and was scattered in the cloud by means of small gun-powder explosions. Rain gauges on the ground showed a slight increase in rainfall. Similar experiments were done with hygroscopic particles. In both cases the evidence was that more rain fell at some distance downwind from the point of release but that there was a reduction in the rainfall directly beneath the point where the chemical was released into the cloud.

In India both dry ice and silver iodide were used for seeding cold clouds and water drops were sprayed into the clouds that were above the freezing point. These experiments were made during the monsoon season when rain occurs naturally so that the results were difficult to evaluate.

In South America numerous experiments were made. Over the Sierras of Cordoba and San Luis in the Argentine dry ice was scattered within a cloud at a temperature of 10°F, but there was no proof that rain fell. Similarly, experiments in Peru were done on cumulus clouds but it was impossible to tell whether the rain that fell was natural or artificial.

In Australian experiments under the direction of Dr. E.G. Bowen of the Commonwealth Scientific and Industrial Research Organization, the evidence was better. By seeding a "suitable cloud", rainfall was certainly obtained, the amount varying from 1 mm at the edge of the shower area to approximately 13 mm (1/2-inch) at the centre.

Seeding clouds with silver iodide

In North America one well-known rain-making operation has been carried out by Dr. Irving Langmuir in New Mexico. He used a silver iodide ground-based generator and carried out regular weekly seedings, using about 1,000 grammes of silver iodide per week over a long period. A large number of other experiments have been made and one careful study of the results indicates a significant increase in rainfall of about 10% above normal. Thus the tendency has become to seek relatively small increases in rainfall rather than to produce rain where there is none.

The report of the World Meteorological Organization is critical of nearly all past experiments, on the basis that they lacked an adequate method of measuring accurately the amount of rain produced and of distinguishing it from natural rainfall. WMO therefore recommends that in future experiments precise methods of measuring the rainfall must be developed. Especially, every operation on a cloud should be considered primarily as a scientific experiment which will lead to an understanding of the basic factors of rainfall and the mechanism by which rain can be induced rather than as a practical operation to produce rainfall then and there on the land below.

Such scientific experiments are now being planned or begun in certain countries and there is hope that more definite results on this very important subject will soon be forthcoming.

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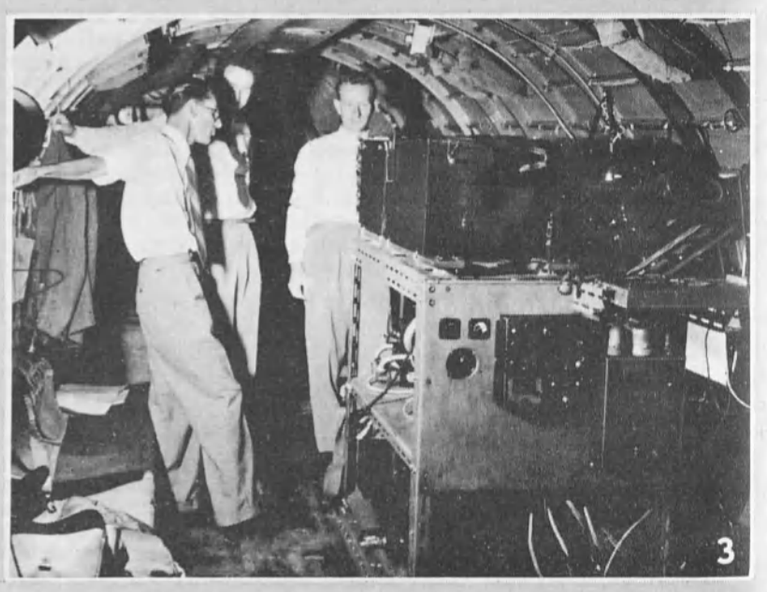
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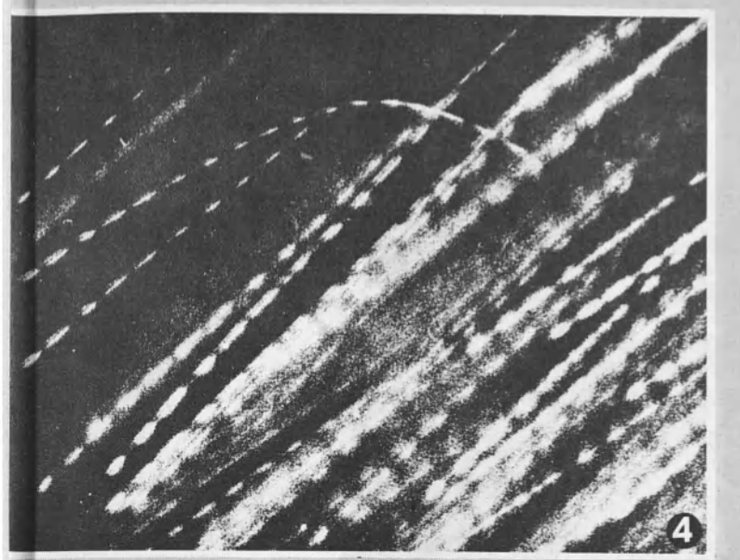
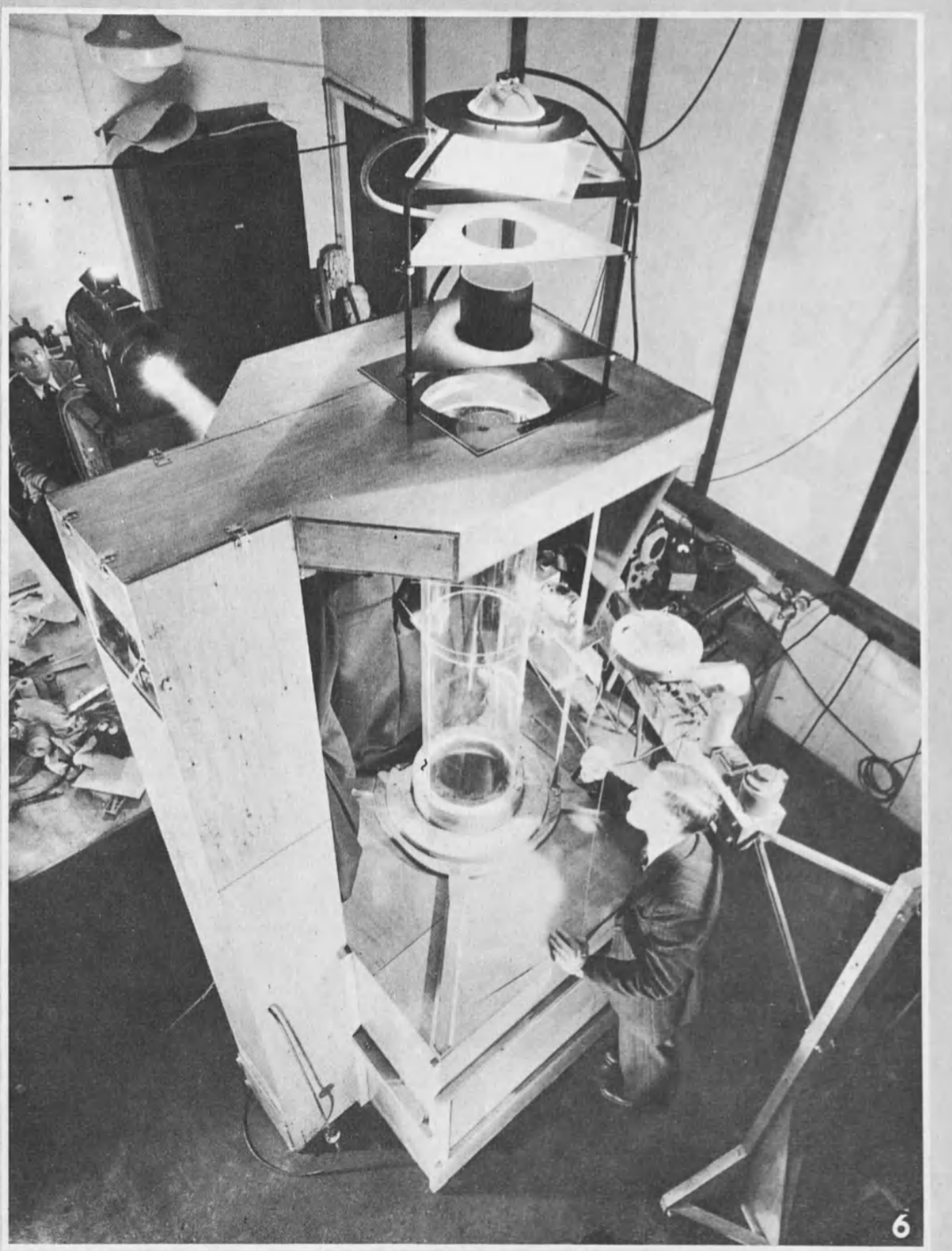


AIRBORNE LABORATORIES

Since 1946, Australian scientists have been carrying out important research into rain-making, combining detailed studies in the laboratory with airborne work in the clouds. Photos on these pages show some of this work being carried out by the Radiophysics Division of the Australian Commonwealth Scientific and Industrial Research Organization.

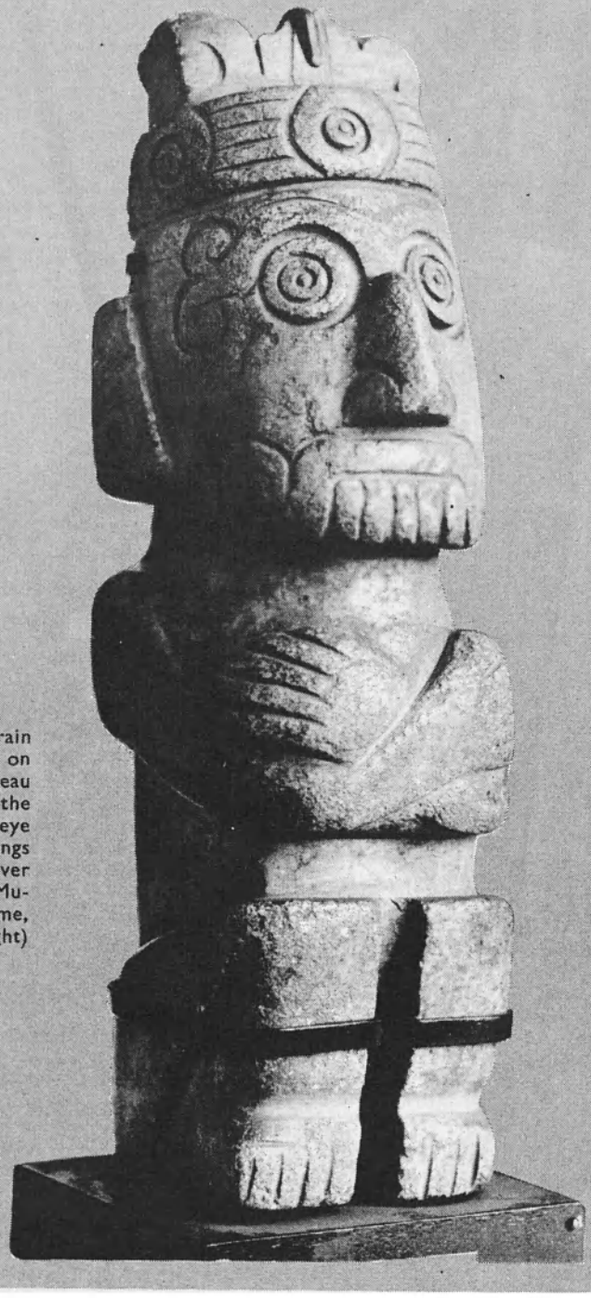
(1) Scientists in aircraft flying through cloud watch instrument recording cloud's water content on moving paper. Impulses are transmitted from another instrument (2) on the front of the aircraft's wing. This houses a continuously-moving paper tape drawn past a narrow slit. Radar equipment (3) in aircraft is also used for observing cloud behaviour.

Twelve-feet high cloud chamber (6) simulates in laboratory the actual conditions obtaining in clouds. Fan in wooden chimney creates a regular updraught of air in the glass chamber into which water is sprayed. Droplets rise gently on the airstream, colliding and combining. Record of their behaviour (4) is taken by a moving camera. In patterns shown here, two droplets which have combined, at left, are beginning to fall towards bottom of the cloud. During airborne operation, stream of salt particles (5) to "seed" clouds is seen falling from aircraft.



Bird-man of Toma tribe, French Guinea taking part in rain-making dance.

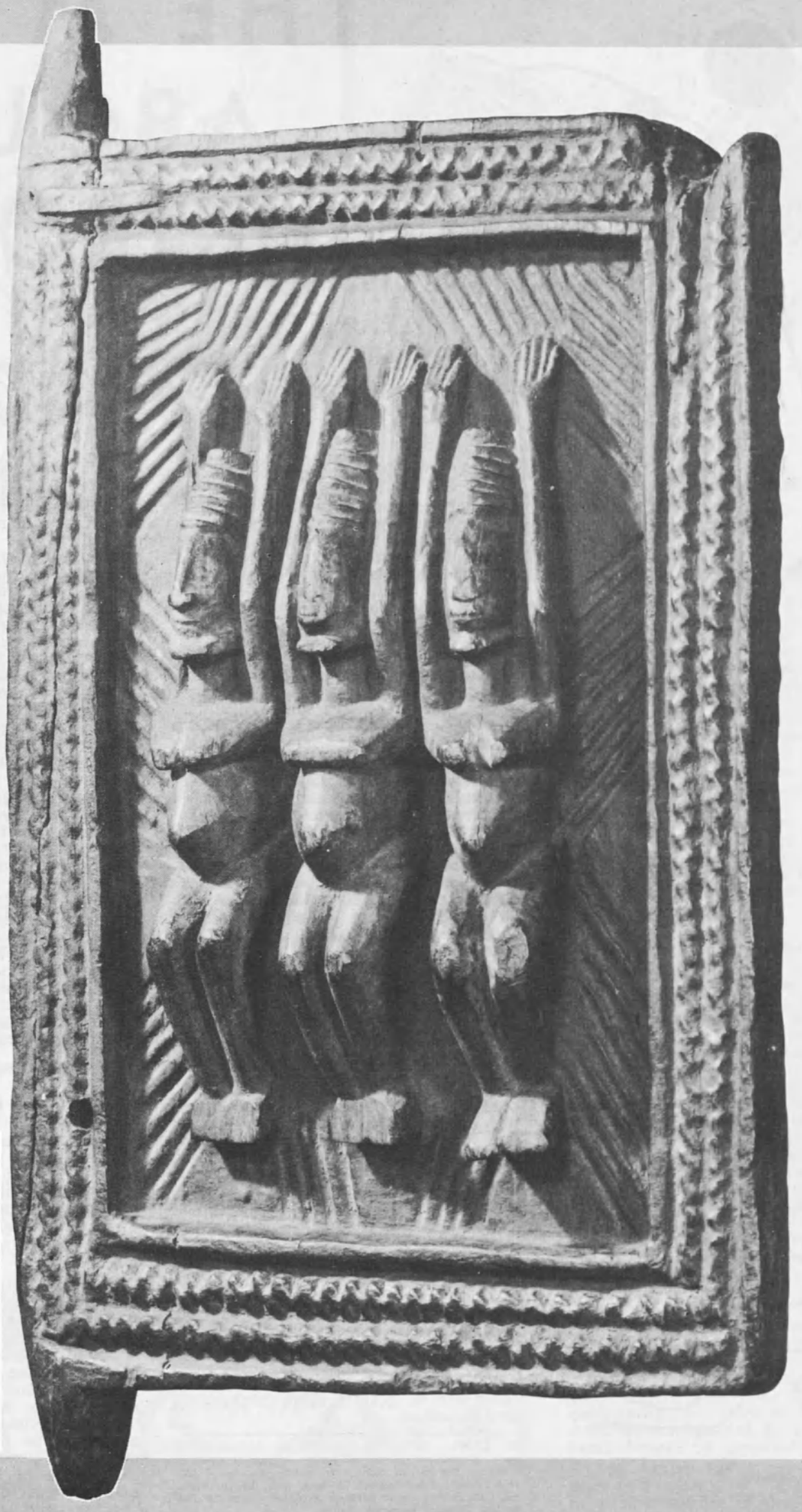
Ceremonial mask which is used by Australian aborigine rain-maker. (Australian Embassy, Paris)



Tlaloc, Aztec rain god. Survival on Mexican plateau depended on the powers in his eye rings, his fangs and volutes over lips. (Photos Musée de l'Homme, Paris. Copyright)

INVOKING THE RAIN GODS

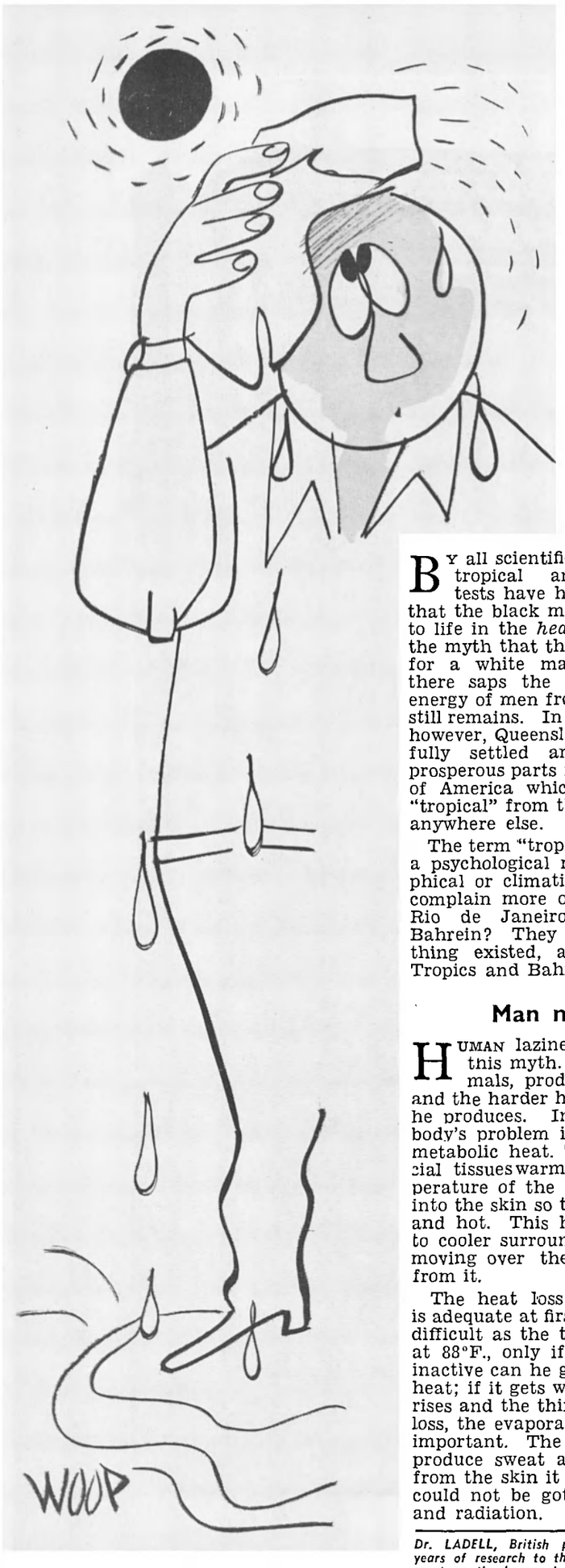
The richest land in the world would be worth almost nothing and people would starve if there were no rain or irrigation. Down through the ages the necessity of rain and the fear of drought have put rain gods and rain-making ceremonies prominently in the religions and mythologies of most of the people of old. In ancient Greece and Rome, Zeus or Jupiter wielding thunder and lightning, was the god of rain and the earth's fertility. In many parts of the world, snakes, serpents and dragons were closely associated with rain and water generally. The Chinese dragon, for example, represented water in all its forms and moods. It was the life-giving rain and rivers without which the earth would be barren, as well as the storm and the sea and the mysterious ebb and flow of water. In India and elsewhere throughout East Asia, the serpent-god Naga had an essentially similar role. The Greeks considered the oak the tree of the gods and dipped an oak branch in water to induce rain. The Romans cast images into the Tiber, and the Teutons poured water over a naked girl. The Druids went to sacred wells or springs in processions where they beat upon the surface of the water or poured water over special stones. The ancient Hebrews looked upon rain as a blessing bestowed by God in return for their obedience to the Law. To the Aztecs, in semi-arid Mexico, the rain god Tlaloc was one of the chief divinities worshipped. Today, rain-making ceremonies and dances still exist in different parts of the world. Primitive rain-makers sprinkle water, use flashes of fire to indicate lightning, make smoke clouds and use drums, clappers and rattles (probably to imitate the sound of thunder or showering rain). Certain African tribes have elaborate ceremonies lasting many days during which chickens, goats and other animals are sacrificed to invoke the gods. Among the Pueblo Indians of the semi-desert southwest U.S.A., feathers are attached to prayer sticks and planted in shrines at springs and irrigation ditches. The annual snake dance of the Hopis and the Rain Dance of the Zunis are both invocations for rain.



The Dogons, an African tribe in the French Sudan, believe that upstretched arms of these three figures link the Earth to the Heavens and thus ensure a bountiful rainfall. (Musée de l'Homme Paris. Photo copyright Draeger)

THE MYTH ABOUT THE TROPICS

by Dr. W.S.S. Ladell



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BY all scientific indications man is a tropical animal. Physiological tests have hitherto failed to show that the black man is any more suited to life in the *heat* than the white, yet the myth that the Tropics are no place for a white man and that sojourn there saps the mental and physical energy of men from temperate climates still remains. In defiance of that myth, however, Queensland has been successfully settled and there are many prosperous parts in the southern States of America which would be rated as "tropical" from their climate were they anywhere else.

The term "tropical" has come to have a psychological rather than a geographical or climatic meaning; do people complain more of Tropical Fatigue in Rio de Janeiro than they do in Bahrein? They ought to, if such a thing existed, as Rio is within the Tropics and Bahrein outside.

Man must sweat

HUMAN laziness is responsible for this myth. Man, like other animals, produces heat as he lives and the harder he works the more heat he produces. In warm climates the body's problem is to get rid of this metabolic heat. To do so, the superficial tissues warm up to the internal temperature of the body and blood flows into the skin so that it becomes flushed and hot. This hot skin radiates heat to cooler surroundings and cooler air moving over the skin takes up heat from it.

The heat loss by these two routes is adequate at first, but it becomes more difficult as the temperature rises until at 88°F., only if a man is naked and inactive can he get rid of his metabolic heat; if it gets warmer his temperature rises and the third mechanism for heat loss, the evaporation of sweat, becomes important. The sweat glands begin to produce sweat and as this evaporates from the skin it takes up the heat that could not be got rid of by convection and radiation.

Dr. LADELL, British physiologist, has devoted many years of research to the influence of tropical environment on the human body. He is now director of the Hot Climate Physiological Research Unit, Lagos, Nigeria. He is also Senior Medical Research Officer of the British Colonial Research Service.

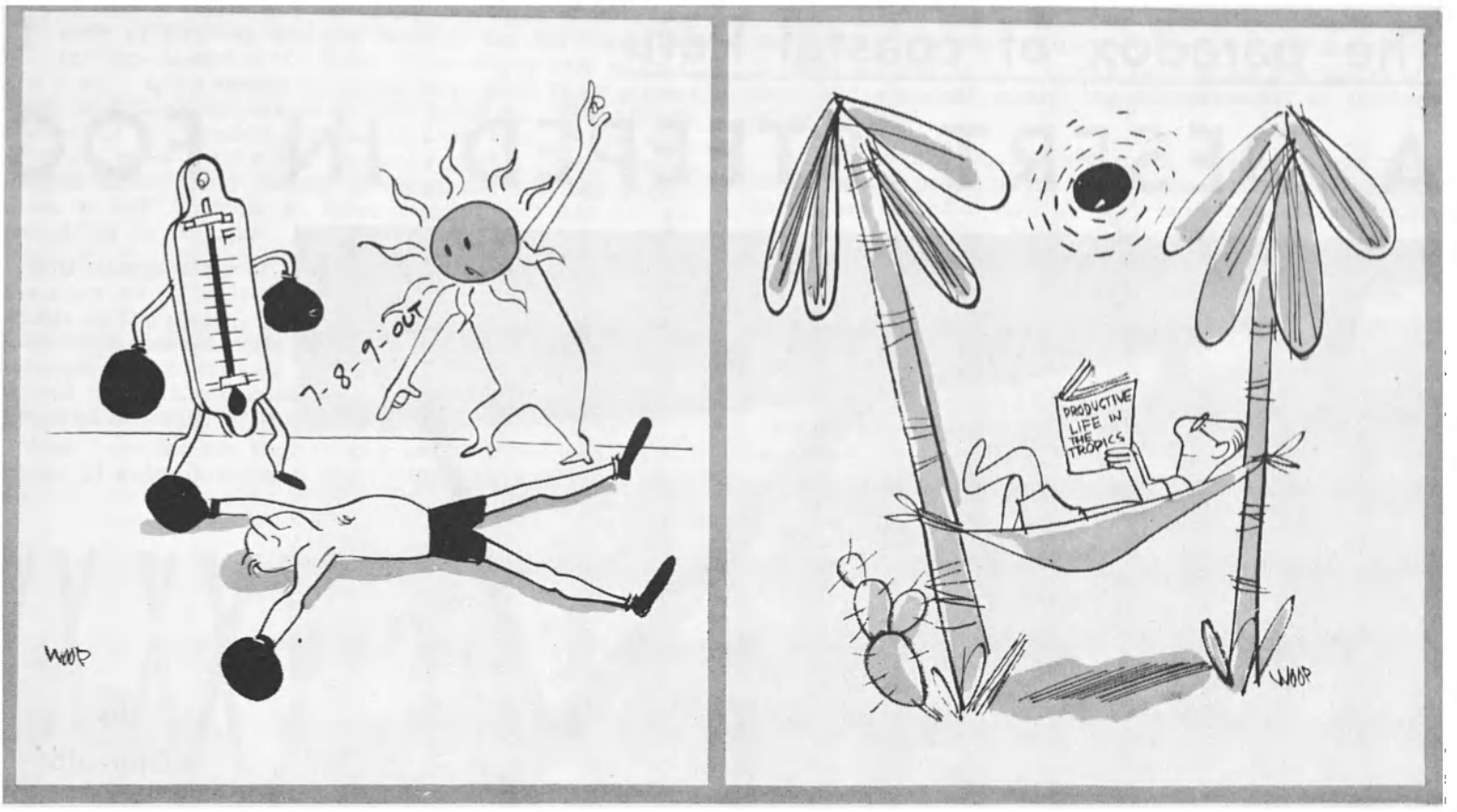
Anything impeding heat loss by these two routes will reduce the temperature at which the sweating mechanism comes into play; for example, a poor flow of air over the skin, or, of course. clothing. Similarly an increase in the total amount of heat to be lost will necessitate sweating sooner; this extra heat may be from working muscles—twice as much heat is produced when strolling at two m.p.h. as when sitting quietly—or it may be acquired externally, as by standing in the sun when the heat gained from solar radiation may be more than that produced by walking at 4 m.p.h.

However, by suitable clothing, by keeping out of the sun and in the breeze, and by not putting up heat production by working, a man can usually avoid sweating, but for a productive life in the Tropics a man must be willing to sweat; in vast areas of the world there is poor nutrition caused in part at least by man's temperamental unwillingness to do so. The same physiologically induced laziness leads to economic difficulties and to dirt and disease and a vicious circle is set up. It is dirt, disease and malnutrition that kills in the Tropics, not the climate.

Modern Adam in Eden

MAN'S cooling system involves two distinct physiological functions. The first concerns the heart and the flow of blood through the skin bringing the metabolic heat to the surface, and the other the production of sweat, the evaporation of which removes heat.

Tests show that a temperate climate man reacts badly to work in heat when he is first tried out; the opening up of blood vessels in the skin drains blood from other parts so that his heart begins to race and he may vomit or faint; sweating is slow in starting and not profuse. But with training the body compensates for the extra blood vessels to be filled by increasing the amount of blood, so that those dangers pass; then he begins to sweat sooner and more freely, and thus becomes "acclimatized to heat". Tests on tro-



pical men, both in Asia and Africa, have shown, surprisingly, that these men react more like untrained temperate climate men than like "fully acclimatized" individuals, and with training they show the same changes.

This is because indigenous tropical man rarely works hard in the heat; he prefers to take life quietly, to move slowly and take no exercise, and to catnap frequently; he avoids sweating and keeps his agricultural activities to the minimum, living when possible as Adam did in Eden. The immigrant to the Tropics, however, who works hard and plays hard becomes nearly completely acclimatized, and thus we have the paradox that he is better able to work in the heat than the locally-born.

But then all around him the immigrant sees the indigenous man cultivating inactivity, sleeping when he can and avoiding hard physical work. Surely, the immigrant asks himself, the local inhabitant must know best; so he too begins to work short hours, and to take a long midday sleep from which he arises confused rather than refreshed to restart his broken day.

When a man sweats he loses water which must be replaced. Physiologically it is best to drink as one sweats, but drinking when at work is often frowned upon; so by evening men have substantial water deficits. Pure water is dull stuff, so the tendency is to make good the deficiency with more interesting alcoholic drinks; compatriots and friends gather together to exchange news and gossip; nostalgia stimulates more drinking; so insidiously an immigrant community becomes mildly but chronically alcoholic and thus develops "Tropical Neurasthenia". Possibly the best tropical settlers are the Moslems who are forbidden by their religion to touch alcohol. But prohibition is not necessary, merely the recognition that to drink water as one sweats is natural and desirable, a sign not of weakness, but of good sense.

Improved living and working conditions, with or without air-conditioning, will help to reduce the heat load, but the settler cannot avoid the heat of the air. Sweat is only praiseworthy when it is the outcome of useful effort; so tractors should be fitted with canopies, and hats should be wide-brimmed enough to shade the whole body from the sun.

The way to productive life in the Tropics is the same as anywhere else; eschew sloth. A tropical community must be prepared to work as hard as it would do in a temperate climate and not be frightened of the heat; by hard work food production can be increased and indigenous diseases eradicated.

Emulate the horse

TROPICAL men must be taught that they are not like cattle, who cannot sweat well and have to rest for half the day to prevent being overheated, even at the risk of starving themselves: men are born with sweat glands so that they may safely work in the heat. The brunt of the day's work must be done before taking a nap. Let communities in these areas develop into fully integrated societies, where isolation and boredom are no longer the lot of every man when his day's work is done, and separation from wife and family the rule rather than the exception for the immigrant.

Recreation must be provided, so that alcohol can revert to its correct role from being a universal hobby to a useful social lubricant. With a real home life and the development of cultural facilities the brain worker too can play his part. But the key above all is the willingness to sweat, and only when much sweat has flowed will a community be able to afford such extravagant luxuries as improving its local climate by air-conditioning.

Only horses sweat; gentlemen perspire and ladies glow. There can never be productive life in the Tropics until humanity emulates the horse.

The paradox of coastal Peru

A DESERT STEEPED IN FOG

All photos by the author

by
Gonzalo
de Reparaz

An Arid Zone Research Institute is being set up in Peru with Unesco aid to mobilize all the resources of science and engineering to wrest production from 1,300 miles of barren coastal regions flanked by craggy mountain terrain towering above them.

THE coastal region of Peru—a thirteen hundred mile-long strip of territory enclosed between the Cordillera and the sea—is one of the most extraordinary arid zones of the world. Quite recent upheavals have given it its present form, and these upheavals are still going on. The average number of earthquakes per year in Lima is about two hundred, but most of them are felt and recorded by the seismographs alone. They merely demonstrate that the earth's crust is still unstable in these regions, and has not yet completed its evolution.

This narrow strip of land along the whole length of the Peruvian coast is traversed by some forty water-courses, which are the source of its wealth. These water-courses have a common characteristic in most of the coastal area: cutting through the mountains in deep valleys or canyons, they spread out in the narrow coastal plain and supply water to irrigated zones of varying extent.

Seen from the air, they form a long, narrow, well-defined ribbon of water, sometimes edged with cultivated land, rising

Peru plans to tap rivers like the Ocona (above) which flow out of the Andes, so as to extend the cultivated lands which today form oases in the dry, coastal belt. Centuries ago the Indians brought water here in hundreds of miles of canals.

up over each bank and spreading out into the plain. But the river is not the only source of water. There is also subterranean water, known to the Indians long before the arrival of the Spaniards.

Archaeologists have found the remains of a complex agricultural civilization which provided the soil for the growth and blossoming of a great culture. The works of its artists, on the one hand, and of its hydraulic engineers on the other, show the full extent of the skill of the Indians.. Their engineers overcame immense difficulties to construct hundreds of miles of canals, thus providing water for the arid land of the coastal belt.

These canals took their water from fifty or more miles up-stream, in the heart of the Cordillera of the Andes. Some of them are still in use. Others have fallen into disuse and their abandonment meant the abandonment of formerly cultivated land.

But this civilization in Peru is not as dead as one might think, for the people of the river oases of the Peruvian coast have never ceased to cultivate their land just as their obscure and distant ancestors laboured before them.

Today, these river oases constitute one of the country's greatest sources of wealth. Though only three per cent of the arid coastal belt is cultivated (about one and a quarter million acres) the output is amazing. These tiny oases produce goods (cotton, sugar, rice) which in 1953 represented fifty-one per cent of Peru's total exports.

Cotton has earned the name of "white gold" in Peru, and each acre of wheat yields more than one and a half tons per annum, in the province of Arequipa. But there are not enough acres under cultivation, and it is imperative to exploit the coastal belt to the maximum by extending its oases and making use of semi-arid land with the help of the new techniques for the utilization of arid and semi-arid soils.

In the development of the coastal belt the subterranean water resources, once used by the Indians, are of vital importance. In Southern Peru plantations have sprung up like mushrooms in the last three years and where all was sand and desert, the waters of the subsoil have enabled many acres of land to be planted with cotton. At Los Castillos, near Ica, four hundred wells have been sunk in the last ten years. Further studies of these underground water supplies are needed so that their possibilities can be fully exploited. An engineer from the Peruvian Ministry of Agriculture recently returned from India and California where, with a Unesco grant, he made a study of methods of location and utilization of subterranean water supplies.

How can water exist beneath the apparently arid surface of Peru's coastal strip ? Some is produced by the infiltration of rivers that come down from the Andes, and some by the heavy fogs, typical of a part of this coast, which condense and seep into the soil.

The Peruvian coast, although so uniform in appearance, has very varied weather conditions. In the North, the extreme dryness of the atmosphere contrasts with the humidity of the sub-soil, and causes vast areas to be covered with steppe-land vegetation. Further to the South, particularly in the central coastal region around Lima, clouds hide the sun for several months of the year, and create the paradox of an arid land, with little rain, where the atmosphere is perpetually saturated with moisture. Still further South, the picture again changes completely. Here the sun reigns supreme and the dryness of the atmosphere reaches a maximum. The "white city" of Arequipa, *(Cont'd on next page)*

Professor DE REPARAZ is a Portuguese Geographer and Cartographer who has devoted many years to the study of climatology and the economic geography of Latin-America and the Iberian peninsula. He is chief of the Unesco Technical Assistance mission to Peru and author of many works on Latin-American and Iberian geography, climatology and economics, as well as on the art, history, literature, etc., of these countries.

A desert steeped in fog *(Continued)*

at the foot of its three extinct, snow-capped volcanoes is the capital of this land of the sun.

In each of these three different regions men are struggling with widely contrasting conditions. Solutions to the problems of the North are likely to be simpler. The diversion of water from the rivers near the frontier of Ecuador offers great possibilities. The Quiroz was recently diverted to supply the river oasis of Piura, which had always been short of water. In the first year increased cotton production had covered the cost of the construction of the canal, a result which must be unique in the world. Further South, the Chancay, the Santa and other rivers also present tremendous possibilities. A few years ago, more than twelve thousand feet up in the Cordillera, the waters of several lagoons which formerly fed the Amazon basin, were diverted to the Rio San Juan. The same thing is now to be done for the Ica, a tremendous undertaking which will enable the oasis to be extended and production to be increased.

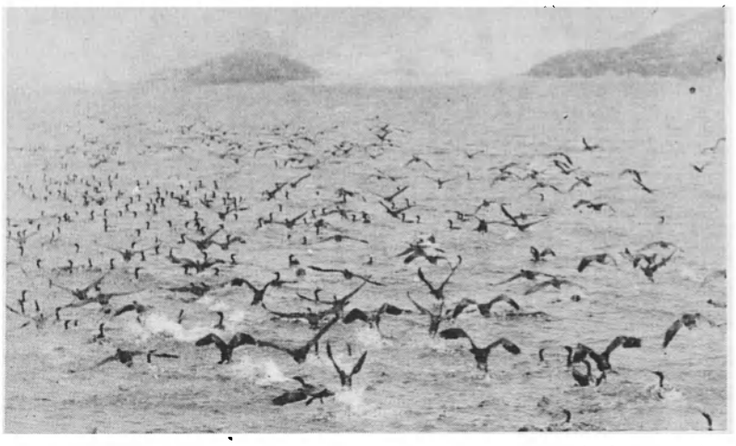
But this work is not yet being carried out on a scale calculated to meet the increased needs of the country, and so vast schemes are being worked out. The people of Arequipa, for example, are tackling the problems presented by Nature with daring, courage and energy, and their problems are much greater than those of the North or even of the centre. Arequipa is seriously overcrowded and feels the constant pressure of an increasing population, while people from the overpopulated Andes plateau (the Puno region and the Peruvian shores of Lake Titicaca) continue to pour in.

Recently I flew over the *pampas* of La Joya, Sihuas and Majes, which are the hope of the "white city" of Arequipa, and which cover many hundreds of thousands of acres to the north of it. Today these vast *pampas* are deserts but they can be placed under cultivation as soon as water can be brought to them from the Sihuas and Majes rivers. Beyond them is the immense Majes Canyon, deeper than the Colorado Canyon, at certain places reaching a depth of nearly two miles. Here, at the bottom of this wild uninhabited gorge, flows South Peru's largest water-course. And it is here that Peru must capture the water that one day will supply the people of Arequipa, by means of a hundred miles or so of channels cut through one of the most rugged regions in the world.

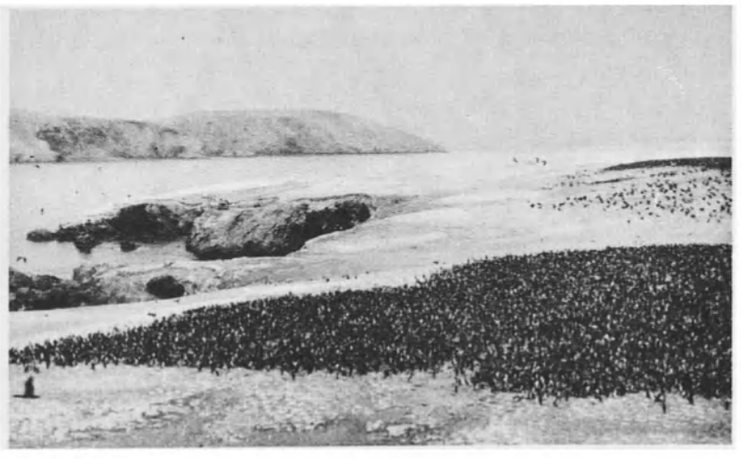
The aridity of these areas of Peru is largely caused by the Humboldt current, a cold current which flows northward up the coast, and also by the cold sea water which rises to the surface from a great depth along the coast of Peru. Their effect is to make the climate of this sub-tropical region colder than it would otherwise be and to cause aridity. It is not a desert, however, for most of the soil along the coast would yield excellent returns if its thirst were quenched with a little water. Much can be done to transform a considerable part of this arid zone into a productive region.

The exceptionally cold coastal waters are also the reason for the amazing wealth of sea-life in the Pacific off the coast of Peru. Few seas are as rich as these—and the best evidence of their abundant fish is the vast number of guano birds living on the islets strung out along the coast. It is the incredible—though not inexhaustible—richness of these waters, that satisfies the voracious appetite of the thirty or forty million birds (their number varies from year to year) which swarm on these islands and produce the valuable fertilizer known as guano. These tiny islands are the most densely populated in the world—in terms of guano birds, *guanayes*, *piqueros*, and *alcatraces* or pelicans. Sometimes their swarming numbers may reach eighty thousand to the acre.

40 MILLION SEA BIRDS



Forty million sea birds swarm on the shore of tiny islands fringing the coast of Peru. Their droppings (guano), richest nitrogenous fertilizer known, once covered islands to depth of 40 to 150 feet. Stripped away in 19 th century, government today protects guano, still one of Peru's richest sources of wealth and vital to prosperity of its coastal farmers.



Thus, thanks to the wealth of the ocean, almost three hundred thousand tons of guano have been obtained from these islands each year by the *Compañia Administradora de Guano*. Today, as at the time of the ancient Indian civilizations, guano is one of the basic elements of agricultural prosperity in the coastal region of Peru, and is indispensable for the survival of the oases in this areas.

The productive output of the coastal belt is today only a fraction of what it might be if modern techniques for the utilization of arid areas were employed. Today we are entering upon an era of geographical planning, and many river basin development projects, creating power for industry and supplying water for agriculture, have shown that whole areas can be completely transformed in this way. There are probably few places in which geographical planning could hope for better results than in the arid regions of Peru.

There are many problems to be solved, and much research is needed. Geographical, climatic and hydrological surveys will have to be undertaken and a thorough study made of the different soils and their characteristics, of the subterranean water resources and of wind as a source of power before plans can be drawn up.

As a first step to carrying out such projects, Unesco has agreed to help the Peruvian Government to set up an Arid Zone Research Institute, thus providing the means of co-ordinating all branches of arid zone research in this part of the world.

THE CAMEL

(Continued from page 32)

However, there are many wild animals in the desert that seem to live so far from any free water that one must assume that they never drink. The desert gazelles, for example, are found far from water holes, and they must subsist on the water obtained from the sparse vegetation upon which they browse. The carnivorous animals, such as the desert fox, obtain a considerable amount of water with the blood and tissue fluids of their prey. Some small rodents eat juicy plant material and cacti, but other very interesting animals eat only dry food.

Among those living on dry food are the jerboas of the Old World deserts, and the kangaroo rats of the American deserts. These rodents are rather similar in appearance and habits, although they are not closely related. They can be trapped easily and when they are kept in captivity it is unnecessary to give them drinking water. In fact they will not drink even if water is offered to them. They can live for months and months eating only dry plant material and dry seeds such as they do in their native deserts. They do not lose weight nor does the water content of their body decrease; in other words, they have no storage of water to tide them over long periods of water deprivation.

These animals contain as much water as other mammals ; about 2/3 of their body is water. They lose water vapour from the lungs when they breathe, and their kidneys use water to produce urine. There is constant water loss from the body ; where does the water come from ?

In experiments with these animals we found that the jerboas as well as the kangaroo rats depend almost entirely on the water that is formed in their bodies by the oxidation of their food. Such oxidation water is formed in the metabolism of all animals, and there is no secret mechanism for chemical manufacture of water; the amount of water depends only on the composition of the food.

Life without drinking

As in the automobile engine, where water is formed during combustion, neither more nor less appears than corresponds to the amount of hydrogen chemically bound in the fuel. The ability of the desert rats to get along on this very limited water supply is due to their water saving mechanisms. They lose only half as much water by evaporation as an ordinary rat. They form very little, but highly concentrated, urine, and they lose a minimum amount of water with the faeces.

It is possible to induce kangaroo rats to drink if they are given food that causes the formation of relatively large quantities of waste products without yielding sufficient water for their elimination. This is the case with any dry food containing a high proportion of protein, which in metabolism yields quantities of urea that must be excreted by the kidney.

We gave some kangaroo rats dry soy beans which contain 40 % of protein, and they would then drink water when it was offered to them. This led us to try to determine whether the kangaroo rats could drink sea water. Other animals cannot tolerate drinking sea water because the organism cannot handle the large extra amount of salt. Indeed, if a man who is stranded without fresh water tries to drink sea water, he is worse off than if he does not drink at all.

We offered kangaroo rats sea water to drink with the soy beans and it turned out that they not only maintained their weight but even gained on this rather severe diet. Of course, in his natural desert habitat the kangaroo rat does not have much use for drinking sea water, but it shows that he can get along on sea water as well as without any water.

In most countries where the cow is of importance in agricultural production there are research centres and experimental stations and farms that deal with problems of scientific and economic importance. This is not so with the camel, although to millions of people over vast areas this animal is of major importance as a beast of burden as well as for production of meat, milk, leather, and wool.

We have often been asked about the practical value of our research on desert animals. Although our primary objective is to increase the amount of basic scientific knowledge in a fascinating field, it is easy to understand that such knowledge is essential to the evaluation of the practical problems that arise in connexion with, for example, the agricultural planning and management of arid land.

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Suggested topics for young people and discussion groups

HISTORICAL

The cradle of civilization—the Valley of the Tigris-Euphrates, Babylon, the former "granary" of the world.
Ancient Egypt. The fertile Nile.
The Mediterranean Empires—Phœnicia and the Forests of Cedars. Palmyra, Baalbek and the "Land of Countless Ruins". Crete. Carthage. Constantinople.
The Aztec Empire in Mexico.

GEOGRAPHICAL

The desert lands of the world: their position on the map—they cover a fourth of the land surface of the globe. Lesser known regions worth further study; the "polygon of drought" on the Brazilian hump; Chile's Atacama desert; Argentina's Patagonian Desert; the Kalahari and Karroo deserts of South Africa; Australia's great "saucer" desert.
Life in the deserts and the scrublands on their fringes; oases; dwellers in the desert and their means of subsistence and transport. The importance of irrigation and annual flooding both in ancient times and today.

SCIENTIFIC

Science applied to agriculture; reclamation of land by irrigation, draining and terracing; soil erosion; new fertilizers; geology and soil chemistry. Underground water; artesian wells; Use of windmills for power in history and today. Protection from wind erosion by maintenance of grass.

Things you can do

1. View "WATER FOR THE PEOPLE", (10 min.) obtainable from Film Division, United Nations, New York, or from regional UN Information Offices.
2. Write for "CONQUEST OF THE DESERT" filmstrip loaned free by Gift Coupon VIA office, Unesco, Paris, or Unesco Gift Coupon Office, United Nations, NY.
3. Display panels from Gift Coupon Photo Series, "MAN AGAINST THE DESERT" available from Unesco in Paris and New York.
4. Arrange showing of Unesco's new film, "BENI-ABBES — SCIENCE IN THE DESERT" (60 min., available free end October) which shows work of research station in heart of south Algerian desert.
5. Join hundreds of other young people in helping Unesco Gift Coupon projects dealing with arid land problems. Example: Gift Coupons are aiding Jaswant College, Jodhpur, India, to study fauna, crop growing environment of Rajasthan Desert.

Letters to the Editor

Sir,

I am a constant reader of the UNESCO COURIER. I was a bit annoyed when you went over to the smaller size, but the tremendous increase in the quality and interest of the articles has more than made up for my disappointment in the format change. I would not like to see it changed back now. Your Pacific Islands issue was particularly notable. How I wish I had had such a reference in college when I was studying Anthropology.

Jay Gluck

Orient Digests,
Tokyo, Japan.

Sir,

Congratulations on your formula of a special theme each month. It is such a pleasant change from the multitude of subjects in those gaudy weekly publications devoted to the doings of political jack-in-the-boxes and the cinema.

R. Gallitti

13, bd du Lac,
Enghien-les-Bains,
France.

Sir,

I should be grateful if you would tell me how I could obtain the book "Albert Einstein, Philosopher-Scientist", published in the U.S.A. as a tribute to Professor Einstein on his 70th birthday.

Daniel Taine

14, rue de Strasbourg,
Cambrai, France.

This, or any other book of a scientific, educational or cultural nature, can be obtained by purchasing Unesco Book Coupons in local currency. In France apply to La Direction des Bibliothèques de France, Service des Bons Unesco, 61, rue de Richelieu, Paris-2e. The Unesco Book Coupon Scheme now functions in 33 countries. Detailed information can be obtained by writing to Book Coupon Service, Unesco, 19, av. Kléber, Paris-16e. - Editor.

Sir,

Sincere congratulations on your excellent puppetry issue. I cannot tell you how many people both in the field and in other lines of endeavours have brought it to my attention. All were delighted with the serious and searching approach used in the compilation of this issue. The wealth of pictorial material was much appreciated.

There is one area, however, which I was sorry to see neglected. That is, the field of puppetry in the United States and Canada where a great deal of vigorous, original work is being produced. May I suggest that at some time in the future you devote an issue of the UNESCO COURIER to North American puppetry? Not only would this serve to define the current status of the art here, but it would also give a great deal of encouragement to our puppeteers who feel at times, I think, that they are crying in the wilderness. In addition, such a publication would be of the most positive interest and importance to puppet enthusiasts in other parts of the world.

Without seeming to cavil, I should like to point out that some of the facts concerning American puppetry published in the June (N° 3/4 European) COURIER are obsolete. There are at least two permanent public puppet theaters in the United States: The Detroit Puppet Theater which we co-sponsor with the Detroit News, and the Turnabout Theater in Los Angeles operated by the Yale Puppeteers. In addition, while it is true that the names of Tony Sarg. Rufus Rose and Remo Bufano are world famous, none of these men is now active in the field strictly speaking. Tony Sarg died in 1942, Remo Bufano in 1948; Rufus Rose now limits his activity to the puppet episodes on the "Howdy Doody" telecast. Such names as Basil Milovsoroff, Romain and Ellen Proctor, George Merten, Martin and Olga Stevens, Cedric and Lee Head, George Latshaw, Spence and Alan Gilmore, Bill and Cora Baird and many more should have been mentioned in addition.

I hope that one day your fine publication will focus its attention on the outstanding work in puppetry now being done in this country and in Canada.

Adolph S. Cavallo

Curator of Theater Arts
Detroit Institute of Arts
Detroit 2, U.S.A.

Sir,

I've read with much interest—and a little dismay—your issue on puppets. The dismay was occasioned by your statement that "there are no permanent public puppet theatres in U.S.A." The Yale Puppeteers, comprising Harry Burnett, Richard Brandon and myself, was organized in 1927 and puppeteering has been our life work. We established the Olvera Street Theatre in Los Angeles in 1929, where we played for two solid years. In 1933, at The Puppet Show in New York we played for six months. On July 10, 1941, we established the present theatre, and we are now starting our fifteenth year of continuous performances. Tonight, I see by my calendar, is the 4163rd. We have produced, in this time, eight complete hour-long musicals with casts of from twenty to sixty puppets, and since the shows are beamed strictly to an adult audience, we're rather proud of our record. We have played to nearly a half-million people, in a theatre seating 172.

Forman Brown

Turnabout Theatre,
716 No. la Cienega Boulevard,
Los Angeles. U.S.A.

SAHARAN ART

centre was nearby. It was inlaid with copper, as "protection against wounds", as well as silver for "the Lord's benediction."

The hilt was studded with typical copper projections to guard against the evil influence of iron, and chiselled with Tuareg designs like the "devil's eyebrows" found on pins and clasps. But it had two additional floral patterns of Arab origin. The subtlety of workmanship pointed to a Moorish origin. Finally, a small cross inscribed in a circle and isolated from the other decorations protected the weapon and its owner from the evil eye.

'I love Touantine'

Now a curious weapon of this kind (curious because of the bayonet form) deserved a signature. And it had one. It was engraved by the blacksmith who made it—a man named Habaia ag Mohammed, who belonged to a Moorish group which had migrated to the Tuareg country 70 years before and which was now in the process of assimilation. But since he was proud of his origin, the blacksmith engraved his name on the dagger and in Moorish fashion tacked on a whole string of his ancestors.

When a Tuareg tribesman later bought the dagger he too decided to immortalize it with a name. And here we find one of the great differences between the Moors and the Tuaregs.

When an escort of Moorish *goumiers* accompanies you on the road, their conversation turns to their ancestors, to God and their salaries; the Tuareg composes poems for the girl he loves. "My beauty with the blue-painted temples, my beauty with the white teeth... I have only the night to accompany the torment of being without you." And he is quite ready to make a hundred and fifty mile detour to serenade her with his poem and the strains of a violin.

It was in this spirit of gallantry, and of the camel race, of the mad dash in the saddle of a fleet-footed thoroughbred *mehari*, just to win a perfumed scarf, that Babou ag Gaba dedicated his new-bought dagger to a woman. His inscription read simply: "I love Touantine".

A knowledge of the Saharan languages, Tifinagh and Hassanya, has revealed what otherwise might have remained unsuspected. In addition to their purely traditional role in decoration, the geometrical pattern wrought on leather, wood and metal sometimes contains intimate personal messages by the artists. Here, for instance, is a short poem by a shoemaker from Mederdra in Mauritania. In the centre of the decoration of his rice bag the shoemaker had, in an explosion of pride, inscribed the following lines:

All men of evil heart will covet you.

(Continued from page 41)

Those I shall not even answer.
For good men would not dare to ask
[for you.

In another instance, when all the ornaments such as "devil's eyebrows", stars, lizards and suns had been removed from a finely stitched bag made in Tamesnar, in the Tuareg country, the entire bag was found to be a message of love. It read:

May the stars accompany you and
[guide your steps.
May the wisdom of the sages be with
[you.
May the Peoples of the Empty Spaces
[retreat from your path.

On a fringe was written this short note of anxious love:

She named Takouani sends many
[greetings to Mertar.
Only the good Lord knows how to look
[into the eyes of Mertar.

Other artists sign a "tassoufra" or cushion as a painter signs his canvas: "This is by me, Amadi."

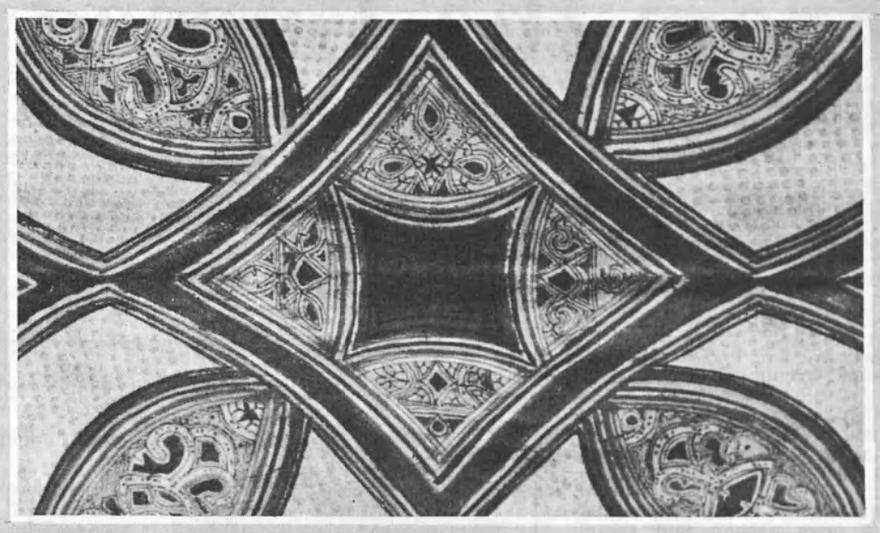
How misleading an obsession with geometrical surfaces and the austerity of their lines can be I realized fully when a young girl, Fathimaton, explained to me: "These are flowers; I saw them on the major's curtains... Here is Limguenfé, the servant girl. You can see, she is on her knees, spinning wool!"

I had been unaware of all the signs in this language of Saharan nomadic art. I had translated them poorly and said, "those are triangles, those are circles and the others there are more curves." But those triangles—just barely recognizable because they were smaller than the others—were the flowers on department store cretonnes. And those curves and the twin voluminous spirals were Limguenfé. The servant girl knew it and recognized herself. Ignoring all the other designs, she touched "her portrait" cautiously and announced with pride "That's me".

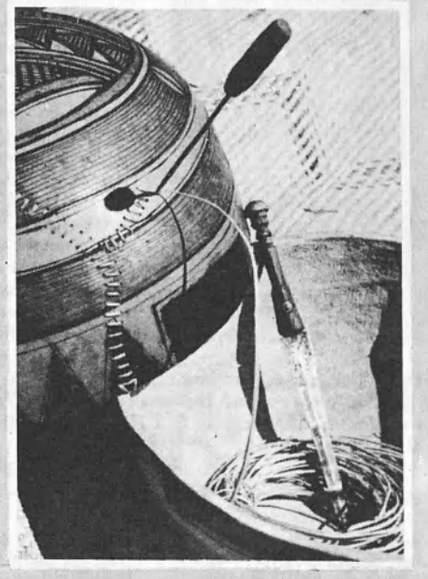
Scorpions, vipers and stars

If one the criteria of art is the expression of human drama in its many forms, then the people of the Sahara desert would certainly seem to offer us an authentic art. Malraux answered the question "What is art?" with this prudent formula: "That by which form becomes style."

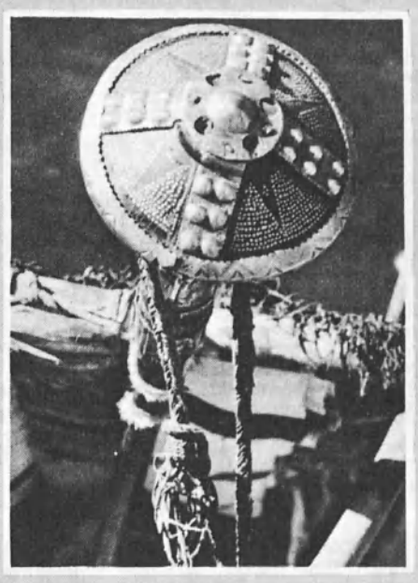
To this definition I might perhaps add those fears and joys which Saharan craftsmen discreetly express with their scorpions and vipers, their stars and suns, with their faith—however naive—in their own art and which they acknowledge in their written messages and through their signatures. We shall then find a close contact—I was going to write between the artists of their world and our own, but shall simply say—between men.



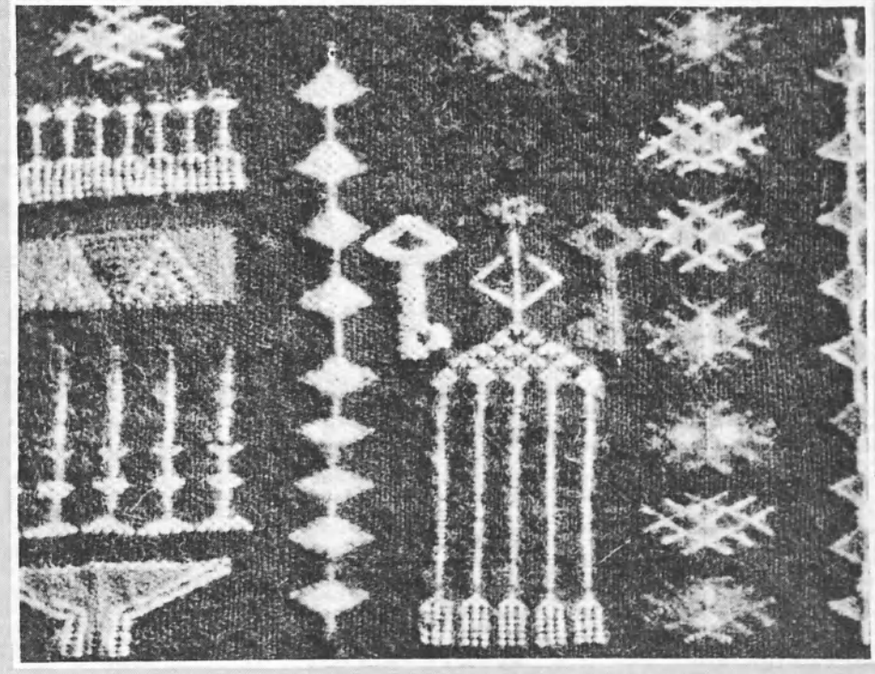
Mat makers of Mauritania use alfa and other grasses often strengthened by thin strips of leather which are painted after the plaiting is complete. In this detail the curved channels represent flowing water. (All photos on this page copyright Jean Gabus)



To decorate a calabash, craftsmen use a sharp knife and a piercing tool to thread thin strips of tamarisk tree bark (coiled in bowl).



Palanquins, placed on camels to transport women and children, are decorated at Hoggar with silver and copper inlays.



Each of the motifs woven into this Mozabite rug has a specific symbolic meaning. Reading from left to right and from bottom to top: a small table, candles in sticks, combs, a scorpion, a finger (called the finger of Tunis) and a key.

From the Unesco Newsroom

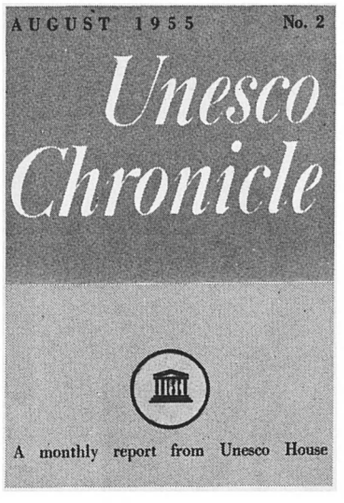
OTHER MEN'S WAYS: The story of Unesco's Exchange of Persons Service, an operation that grew out of the tremendous rise of educational exchanges and study abroad in the past three decades, has now been told in "Other Men's Ways", the latest pamphlet in the "Unesco and its Programme" series. The pamphlet presents a picture of what Unesco has been able to do since 1947 to establish personal contacts between people from different lands. Some of the things Unesco has done to smooth the path of educational travel, such as collecting and making available information on fellowships, vacation study opportunities, teaching posts open abroad and travel reductions and facilities, are described. Unesco itself has offered nearly 1,000 fellowships over the past eight years, and its exchange of workers scheme has already helped three thousand European workers to undertake study tours abroad. Today an estimated 100,000 students are studying in foreign countries.

★ **GOING UP:** *The world's population totalled* 2,528,000,000 *in the second half of* 1954, *compared with* 2,493,000,000 *in* 1953, *according to an analysis made by the United Nations Statistical Office. Totals for different world areas were as follows: Africa:* 216,000.000; *North America:* 233,000,000; *South America:* 121,100,000; *Asia (excluding U.S.S.R.):* 1,323,000,000; *Europe (excluding U.S.S.R.):* 406 500.000; *Oceania:* 14,200,000; *U.S.S.R.:* 214,500,000.

PEOPLE ON MISSIONS: Canadian film maker, Graham Crabtree, is now in Indonesia to help the authorities there set up an audio-visual production unit at the Bandoeng teacher training centre. Mr. Crabtree who is working on a Unesco technical assistance mission, did a similar mission in Thailand in 1953. Among the many other specialists now carrying Unesco technical missions in various parts of the work, three have just joined the Unesco team working in Liberia. One is Dr. Juntaro Kawai, a Japanese chemist, who will join the faculty of the University of Liberia in Monrovia, capital of the West African republic. A second is a British physicist, Dr. J. Aharoni, and the third is Mr. Erling Rossing, Danish educator. They, too, will join the University staff and help Liberia expand facilities for science teaching. At the same time, Unesco has sent a British librarian, Mrs. Lucia Moholy, to Turkey where she will work with authorities in establishing a scientific documentation service.

★ **CULTURAL 'RED CROSS':** *Egypt is the first country to ratify the "Blue and White Shield" agreement, an international Convention for the Protection of Cultural Property in the Event of Armed Conflict. The agreement will come into force after it has been ratified by five countries. It was adopted at an intergovernmental conference convened by Unesco in May* 1954 *at the Hague. It sets up what is tantamount to a cultural "Red Cross", under whose banner works of art, monuments and historic buildings would receive the same sort of protection in time of war that is now universally given to hospitals, ambulances and medical personnel. Countries who sign also pledge themselves to take a number of unprecedented peace-time measures. The banner symbolizing this international agreement is a blue flag with a white shield. It is significant that Egypt, a country rich in culture and artistic treasures, should have become the first to ratify this convention, which marks an important step forward in international law.*

Monthly chronicle replaces Unesco's quarterly bulletin



A new monthly magazine has replaced the Unesco Quarterly Bulletin and the Unesco Newsletter, combining the editorial features of both. The first issue of the new Unesco Chronicle, which is published in English, French and Spanish, appeared in July. The editorial format includes, besides reports on Unesco activities at the international and regional levels, a monthly letter to Member States, and a review of administrative matters at headquarters. Also included is a review of work being carried on in the field and an editorial on some special aspect of Unesco's programme. In addition, each issue will contain reviews of the most recent Unesco publications, full information on decisions adopted, work in progress and the results achieved. Yearly subscription to the Unesco Chronicle is $ 1.75; 10/6; 500 fr. Individual copies : $.20; 1/-; 50 fr.

LOW-COST LABS: Sets of one hundred and fifty-six drawings to enable schools in tropical countries to build low-cost science teaching laboratories have just been issued by Unesco. With these drawings a laboratory can now be produced at about a third its market price. The drawings cover equipment needed in primary and secondary science teaching, and in the training of science teachers. They will particularly aid countries which are short of science teaching equipment and lack foreign exchange to import apparatus, yet which have craftsmen and vocational schools where the equipment might be manufactured locally at low cost.

★ **PRISONERS' RIGHTS:** *The first U. N. World Congress on the Prevention of Crime and the Treatment of Offenders was held recently in Geneva, Switzerland. The* 400 *delegates, who included social scientists, criminologists, research workers, prison wardens, juvenile court judges and social workers, discussed, among other subjects, a basic set of international rules for the treatment of prisoners, as well as ways of preventing juvenile delinquency.*

WHERE COLOUR COUNTS: Coloured filmstrips used for educational work more than justify their increased cost over black and white ones because of their added power of persuasion according to experiments carried out at the Latin American Regional Fundamental Education Centre, Patzcuaro, Mexico. Over 200 copies of filmstrips covering every aspect of community improvement from animal vaccination to rural architecture have been sent out by the centre to five countries—Nicaragua, Cuba, Venezuela, Puerto Rico and Mexico. Students at the Centre which is operated jointly by Unesco, the Organization of American States and the Mexican Government, used filmstrips in some twenty Tarascan Indian villages where they taught and also learned some techniques to apply in their own countries.

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Canada : University of Toronto Press, Toronto.
Ceylon : Lake House Bookshop, The Associated Newspapers of Ceylon, Ltd., P.O. Box 244, Colombo I. Rs. 5.
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A NOTE TO OUR READERS

It is now almost two years since the Unesco Courier abandoned its tabloid newspaper size and adopted the present magazine format. Since then no effort has been spared by the Editors to improve the appearance and the contents of each succeeding issue. New features and columns have been added, the number of pages has been increased, and a high quality whiter paper is now being used both for the cover in colour and the inside pages. The response of our readers throughout the world to these and other improvements has been most gratifying.

Though the Unesco Courier is a non-profit publication the present annual subscription rate of 300 fr. francs, or 6/- no longer even covers printing and postage costs. It has therefore become necessary to announce an increase in price. Nevertheless, to permit the Unesco Courier to continue to reach the widest possible number of readers, this increase has been kept to an absolute minimum.

As of January 1, 1956 the new subscription rate will be 400 French francs, 8/- or $2.00 per year. The per copy rate will be 40 francs, 9d., 20 cents. New subscriptions and renewals will be accepted at the current rates if postmarked not later than December 31, 1955. DON'T WAIT — SUBSCRIBE OR RENEW YOUR SUBSCRIPTION TODAY.

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★ The chances of peace, and of economic progress and social betterment.

★ A scientist takes a realistic look at the International Atom.

The UNESCO Courier
A WINDOW OPEN ON THE WORLD

SOLAR FURNACE IN THE PYRENEES

Giant mirror, being inspected by scientist at Solar Energy Laboratory, Mont-Louis, France, is over 30 feet in diameter and comprises more than 3,500 pieces of glass. By concentrating reflected rays of sun into the orifice of a solar furnace it creates temperatures of around 3,000 degrees Centigrade. Recent research aimed at harnessing sun's energy is of vital importance for the future of power-poor arid zones. See page 25. (Photo Solar Energy Laboratory, Mont-Louis)